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NOTES

ON

FOREST PROTECTION IN BURMA

BY

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PREFACE.

THE following notes have been collected mainly from official publications such as "Departmental Instructions for Forest Officers,". "Burma Forest Manual," "Standing Orders for Subordinates," Lecture Notes, Bulletins and Records issued by the Imperial Research Institute at Dehra Dun, various Working Plans, and an old Manual of Forest Protection by an unnamed author published by the Government of Burma in 1903. For other assistance I am indebted to Dr. F. J. Meggitt, Professor of Biology in the University of Rangoon, who kindly checked the portions referring to Zoology and Entomology, also to Messrs. H. W. A. Watson, I.F.S., and A. H. M. Barrington, I.F.S., who both read the manuscript and made a number of valuable suggestions which have been incorporated.

The notes refer mostly to Burma since they are intended for the use of students in the B.Sc. (Forestry), and Diploma in Forestry, classes in Rangoon University but as there is no other book on the subject dealing with this part of the tropics in particular it is hoped that the work may be found of wider interest.

The very elementary references to Zoology and Entomology are not intended to replace a course of study in these subjects but to make the notes more intelligible should they be read by officers without any knowledge of these subjects.

R. UNWIN.

UNIVERSITY COLLEGE, RANGOON,
September 1927.

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INTRODUCTION.

THE oldest branch of Forestry is Utilization which has been practised ever since the human race was sufficiently advanced enough in civilization to need forest produce. As time passed the needs of men increased as well as their numbers, cultivation spread, and the demands on the remaining forest became greater and greater. So long as the population was small and scattered over the thickly forested lands, indeed for a long time after these conditions had disappeared, forest produce was considered like air and water as a gift of nature to be used freely by everyone. Later on it became a matter of concern to people living near forests whether the latter would continue to supply their wants; consequently individuals and communities began to assert ownership with the idea of reserving the produce for themselves as against outsiders. With this idea there arose the branch of Forestry known as *Forest Protection* which was originally designed against Man alone but which developed in course of time to include measures of protection against damage of all kinds, both direct and indirect.

In the older countries of the world the stage of protection against Man was reached many years ago but in Burma, owing to the scattered population and very large supplies of Forest produce, until quite recently there seemed no necessity for any alarm. There has been a great change however during the last generation and already in some places, particularly in Lower Burma, there is great inconvenience from lack of accessible supplies. The need of protection of the remaining sources of supply is correspondingly now becoming more urgent, and since the people most concerned are as a rule slow to appreciate the necessity it is an urgent duty of the Forest Department to impress it upon them as strongly as possible.

The main causes of damage can be roughly classified as follows :—

I.—Man.	III.—Plants.
II.—Animals.	IV.—Natural Phenomena.

Of these Man is probably still the most important. He certainly is from the point of view of Protection as it is usually more practicable to devise means of keeping his harmful activities in check than to prevent the spread of a fungal disease or a woodboring caterpillar. Measures of Protection against animals, particularly insects, and harmful plants such as Fungi depend on a knowledge of the habits and life history of the insect or plant concerned and much research into these matters is frequently necessary before really adequate protective action can be taken.

Direct injury results from destruction of timber, trampling down of young growth, burning, etc., while indirect injury may result from damage to trees leaving wounds through which diseases or decay find it easy to enter.

In this book the various kinds of injury likely to occur in Burma will be dealt with under the four main headings mentioned above. Since the Fauna is as much a part of the forest as the Flora its protection is included in the appropriate place.

NOTES

ON

FOREST PROTECTION IN BURMA

PART I.

Protection against Man.

CHAPTER I.

LEGAL PROTECTION.

1. The basis of protection of forests against Man is the Burma Forest Act (1902) as subsequently amended and the Rules and Regulations framed on the authority of that Act. The necessity of a special law to apply to Forests will doubtless be explained in greater detail in the course on Forest Law but briefly it may be stated here that the Indian Penal Code and the Criminal Procedure Code do not deal in sufficient detail with subjects which are absolutely vital to Forests. Under the Forest Act however many acts which would otherwise be legal are specially forbidden and penalties are prescribed for all offences which might conceivably be committed against forests, including forest produce. The Act prescribes the method by which any area of forest can be constituted a *Reserved Forest* and the special rules which will apply to such a *Reserved Forest* as compared with *Public Forest Land* (or as it is usually called "*Unclassed Forest*"). Speaking generally, in a Reserved Forest all acts are prohibited save those specially permitted by Government whereas in Unclassed Forest any acts, save those expressly prohibited, are legal.

2. It follows from the above that care must be taken to demarcate, without leaving possibility of doubt, between Reserved Forest and Public Forest Land. A legal act on one side of the boundary may be a forest offence punishable with

fine or imprisonment, or both, on the other side so that it is necessary for the inhabitants of such a locality to know the exact boundary and it is only just and right under the circumstances that the Forest Department should make it clearly visible.

3. In addition to complete protection of forest growth in Reserved Forests the law enables the Local Government to declare certain species to be "Reserved" trees. Thus teak *wherever situated* is declared to be the property of Government and a number of other trees, usually either valuable kinds, or in certain cases rather rare species, standing on land at the disposal of Government are protected from utilization or injury save in accordance with special rules.

CHAPTER II.

Boundaries and Demarcation.

4. Most of the remarks under this head apply to Reserved Forests only as these alone are demarcated and come under the closer control of the Department through the provisions of the Forest Act. Injury to the forest may result from encroachment particularly if the boundary adjoins cultivation or is near a populous area. Numerous instances have come to light in which boundaries have been set back with considerable loss to Government through the removal of the produce standing on the area thus stolen from the Reserve, as well as the loss of the land itself. Such fraud is especially likely where land is valuable; for example around a Forest Timber Depôt in a town on the railway line as well as in connection with Reserve boundaries. It is therefore important to choose boundaries with care; once chosen to demarcate them clearly and to keep such a record that even if destroyed they can be pointed out on the ground again with absolute certainty. In the case of the ordinary Forest Reserves these objects can usually be attained by using natural features such as watersheds and streams. Roads (except permanently graded ones), firelines, etc., are not suitable as boundaries.

Departmental Instructions for Forest Officers in Burma, 31—43; Manual of Standing Orders for Forest Subordinates, 100—124.

5. Methods of demarcation vary from place to place to suit varying circumstances and it would serve no useful purpose to repeat all the details here. It will suffice to state that in general well defined features used as boundaries need little demarcation

except at places where a road or path crosses the boundary while ill-defined features and boundaries following an artificial line, especially near cultivation and villages, require as thorough a treatment as is consistent with due economy. It should be remembered that poor work, though cheap, will soon need repair and may be more expensive in the end. A survey should be carried out from post to post, in conjunction with the demarcation, by means of the Prismatic Compass. When a Reserve is likely to be surveyed by the Survey of India, such survey (*i.e.*, by Survey of India), is sufficient to define the boundary for legal purposes. It is very necessary to preserve this record of the boundary in case of future dispute or fraudulent removal of boundary marks. It goes without saying that care must be taken to see that the demarcation follows the true boundary as originally notified and that once carried out the demarcation is kept in proper repair. Ordinarily the method of demarcating with wooden boundary pillars, blazed trees and boundary boards will be found sufficient provided that the position of each pillar is accurately surveyed and recorded with reference to some fixed point but in the case of a timber depôt or Revenue Station it may be advisable to use brick or concrete pillars which are more permanent than wooden posts.

It is suggested with a view to improving both permanence and ease of upkeep that boundary lines on the flat should be dead straight while an artificial line in hilly country may usefully follow a graded path specially aligned and made for the purpose. Ditches joining masonry pillars are a possibility in Lower Burma.

6. Owing to faulty description, proposal of boundaries without the assistance of a map, etc., present day boundaries could in certain cases be improved by comparatively simple alterations. This possibility should be kept in mind and action taken to re-notify and re-demarcate such boundaries as opportunity arises.

7. Unfortunately the steps detailed in this chapter have not always been carried out and of late years, especially in Lower Burma where the pressure of cultivation is greater, grave trouble has been experienced as a result.

8. Students should familiarize themselves with the latest standing orders of Government and the administrative officers of the Forest Department on the whole subject of Boundaries and Demarcation.

CHAPTER III.

FOREST OFFENCES.

9. The Burma Forest Act prohibits certain acts both in Reserved and Unclassed Forests and prescribes rules for the general protection of Forests and Forest Produce. A breach of any such rule or regulation entails liability to a penalty and is described as a Forest Offence. Offences consist mainly of harmful acts such as theft of produce and damage to growing forests, or breaches of rules designed to protect forests from damage and to render the detection of offences more easy. To mention each kind of offence would be to reproduce the greater part of the Burma Forest Manual so that the main heads will be discussed on general lines leaving the student to supplement his knowledge by a study of the Act and the Manual for himself, in addition to the explanations of these which will be given in the lectures on Forest Law.

10. Direct theft is a simple matter and the necessity for its punishment is self-evident but the detection of theft is by no means so simple. Protection is afforded by direct means such as patrol by beat officers and grant of rewards to informers combined with punishment of offenders when caught. Indirect protection is afforded by rules such as those requiring saw-mills and saw-pits to be licensed or requiring a pass to be taken out before timber can be moved. These rules make it more difficult to dispose of stolen produce on a large scale. Minor theft by villagers to supply their own personal wants is more difficult to stop but can be prevented to some extent by making available such produce as they require at rates which they can afford. Of late years there has been considerable development of the daily ticket system for extraction of domestic produce. These tickets are sold on a small commission by local people who are on the spot and who for the sake of their commission induce the people to buy tickets rather than steal their needs. Frequent and thorough inspection of all forests in their beats by subordinates should be insisted upon and failure on their part to report known offences should be treated as serious neglect of duty.

11. Damage to the forest or its produce may result from illicit grazing, felling, girdling or otherwise damaging trees, kindling fire, breaking up forest land for cultivation*,

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* NOTE.—This refers to Reserves. "Taungya" cultivation is permitted in Unclassed Forests save those protected from it under Rule 19, Burma Forest Act.

dynamiting or poisoning streams and by hunting or fishing, etc. Such damage as this can be kept in check by patrol and inspection followed by punishment of offenders when detected as in the case of theft. Damage may be done either wilfully or for want of due care by persons otherwise acting legally. For example a licensee or lessee may damage adjoining trees by careless felling or careless collection or extraction of other produce such as "lac" or honey; his action in felling or collection or extraction being otherwise quite in order. Damage of this kind although it may be a breach of the Act is sometimes also provided against by conditions of the license (or lease, or contract) for breaches of which penalties are exacted. Similarly any person legally extracting forest produce is bound to obey the provisions of the Act with regard to the registration of his hammer marks and the manner in which they must be used, the rules regarding timber in transit, taking out of a license for a saw-pit or saw-mill, etc. Breaches of such rules can be punished under the Act but it is usual in drawing up contracts to include some or all of these with the addition of any special restrictions or conditions which may be thought desirable. Breaches of these conditions can then be dealt with as breaches of the contract or lease instead of under the Act and in some cases this is desirable. This subject is also dealt with in connection with leases, contracts and licenses which will be explained in more detail in the lectures on Forest Utilization. It is important to remember that the forms for these licenses and contracts have been devised after years of study and experience so as to cover all probable difficulties. Extraction should therefore be permitted only on the authority of a sanctioned form of contract or lease and the terms of such forms should be altered as little as possible. It should also be borne in mind that although control is facilitated by rules, etc., designed to prevent theft or damage yet the ultimate and real protection lies in adequate inspection of the forests which alone can prevent offences, whereas what may be called paper checks or controls merely assist in detecting the offender *after the damage has been done.*

12. *Punishment of Offences.*—The Forest Act provides penalties, for the various classes of offences, which may be inflicted by a Magistrate but it also provides for compounding of cases under certain rules by certain classes of Forest Officers. The maximum limit of penalty is Rs. 50 *plus* the value of the produce concerned, if any. The latter method is much the more commonly used as it avoids the delay and trouble

involved in a prosecution in Court. It should however be used only for minor cases and not for serious offences or where the person concerned is an old or habitual offender. In times and circumstances where efforts to prevent offences seem to be failing good results are frequently effected by prosecution, carefully and strongly organised, with the attendant risk for the offender of imprisonment and the stigma attaching thereto instead of a fine of Rs. 50 which can perhaps easily be paid. When cases are prosecuted, the prosecuting officer should lay before the Court any previous convictions against the accused.

CHAPTER IV.

PREVENTION OF WASTE.

13. *Waste in Extraction.*—Much timber and other forest produce is wasted through careless felling, logging and conversion while in some cases it is deliberately rejected because of minor defects which although they render the produce less valuable do not make it unmarketable or useless. Also trees are felled and only part of the marketable timber is extracted. All leases, licenses or contracts contain conditions requiring all the useful produce to be extracted and royalty to be paid thereon, so it is necessary constantly to supervise the work of licensees and contractors to see that they observe the conditions. In order to make certain it is best to insist on measurement and marking of timber *at stump* when it is easy to see if there has been any waste. This procedure also ensures that every stump shall be visited by the measuring officer who at the same time sees that the actual trees felled were legally available. If measurement and royalty marking is done at a distance from the felling site inspection is not likely to be so adequate and opportunity for breach of conditions is greater. On the other hand, unless the area is accessible and the measuring staff sufficient considerable inconvenience and loss may be suffered by contractors through failure to get their logs marked when they wish to have them done. An obvious opportunity is also opened to dishonest subordinates. While therefore marking at stump is the ideal method it may not always be practicable and if it is enforced special steps must also be taken to prevent any abuse and to ensure prompt attention

to requests by traders for measurement. For these reasons the method is nowadays only permitted in special cases.

14. The above remarks apply to cases in which trees are felled and the logs obtained presented for measurement on which royalty is paid, as under an ordinary trade license. An improvement on the method is now frequently used especially in Reserves in which there is competition for the produce. In such cases the right to work any particular coupe or number of trees is sold for a lump sum in addition to which the purchaser pays royalty at license rates on whatever he extracts. Under these circumstances the more outturn he can get the less will be the average price per ton, so that the contractor has less inducement to leave marketable produce behind. He also has inducement to fell trees to which he is not entitled and therefore inspection is constantly required to prevent this form of fraud. Under some of these contracts the contractor is bound to extract all marketable timber and in addition may have the right to convert lop and top and certain unmarketable kinds of trees into fuel or charcoal on which a very low rate of royalty is paid ; usually nine or ten annas for one hundred cubic feet stacked. Care must be taken to see that logs on which royalty at timber rates should be paid are not converted into fuel, with consequent loss to Government.

15. Another method of sale, which is however not commonly used in Burma, is to sell outright all the produce in a coupe, or a certain number of marked trees, for a lump sum. It is then in the purchaser's interest to waste as little as possible though care must be exercised to prevent removal of produce not included in the sale. Unless clear felling is intended this method is not often adopted.

16. The following are the commonest examples of wasteful felling and logging :—

Felling too high.—Felling should be as close to the ground as possible and never more than three feet high unless the butt is hollow or unsound.

Careless Felling.—Trees should be felled so as to avoid damaging themselves or other trees in their fall, *i.e.*, they should be felled uphill if possible and never across (or into) ravines, other tree trunks or boulders thus smashing or splitting the timber or felling it into a position from which it cannot be extracted.

Wasteful Logging.—Logging should be by the saw, not by the axe, and all sound marketable timber should be taken out. It is often left at one end of the log as well as in whole pieces.

In connection with wasteful extraction inspecting officers have to take into account the species of timber and its market value. For instance a Teak branch may be worth quite a good sum whereas a similar piece of inferior junglewood may not be worth extraction even as fuel.

Loss by Fire.—All marketable logs and trees felled must be protected from fire by the extraction agency until royalty has been paid and the interest of Government ceases. These and other matters are always included in the conditions of leases, licenses and contracts but observance depends finally of course on adequate inspection and control of fellings by beat officers backed up by visits as frequently as possible by Range Officers, the Divisional Forest Officer, and his Assistants.

17. *Collection of Minor Forest Produce.*—This must be controlled so that the supply may not be exhausted once and for all by excessive or harmful methods. For example a collector should not be allowed to remove all the living "lac" from a tree or to fell the latter to obtain the "lac." No *in* or *thitsi* tree may be tapped for resin if under 3 feet in girth (since this would be liable to injure the tree unduly). Similarly *kanyin** trees under 6 feet may not be tapped, while collection of edible bird's nests and the destruction of young birds or eggs between 15th April and 30th June (the breeding season) are prohibited. Many other examples will come to mind but it is sufficient here to lay down the general principles which are that collection should be permitted only on conditions which prohibit—

(*a*) extinction of the source of supply
(*b*) damage to other producei; and some times
(*c*) the adulteration of the product (as in the case of cutch to which bark extracts notably *thansha* are occasionally added.)

CHAPTER V.

ABUSE OF FOREST RIGHTS.

18. At the time of constitution of a reserve, or at the Settlement as the procedure is usually described, certain rights are frequently granted to the local inhabitants whose liberty to use forest produce has been curtailed by the

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NOTE :—* *Kanyin* is reserved tree in Lower Burma and ordinarily no tapping of it should be allowed.

reservation. These usually include rights to extract timber and fuel for domestic, agricultural or piscatorial uses ; to extract bamboos and canes for the same purposes ; to collect edible fruits, honey, beeswax, fungi and roots, to catch fish, tortoises and iguanas, etc.; to collect grass or leaves for thatching ; to graze animals and to make use of roads or paths in the reserve. The produce must not be bartered or sold and the provisions of the Forest Act and Rules must always be observed. From the comparatively minor character of the individual items and their scattered nature this extraction by right-holders is difficult to control but of the many varieties of rights only those to timber, bamboos, canes and to grazing are really important. Even if abused the other rights do no very considerable or lasting harm to the forest estate and therefore no particular effort is usually made to supervise their exercise save in cases in which fire protection is being carried out. Then it may be necessary to take special steps to prevent wilful or accidental firing during lawful extraction by right-holders.

19. In the case of new settlements it is desirable if rights are to be granted at all to see that they are very definitely stated ; for example the persons to whom rights are granted should be specially mentioned and the area within which the rights may be exercised should be defined. The aim of the Forest Officer advising the Forest Settlement Officer should be to confine the area burdened by rights to definite limits and to leave as much as possible unburdened. Naturally the amounts of produce granted must not exceed the needs of each case nor must the total exceed the capacity of the forest.

20. Generally speaking, in out-of-the-way tracts when there is little or no trade in forest produce, right-holders extract their requirements with little trouble and only ordinary supervision and inspection is needed. In other places however there is very considerable loss and damage by illicit extraction of timber for trade purposes under the cloak of extraction by right-holders. In such cases the rights can be controlled by the Local Government under the conditions laid down in Circular No. 56 of 1907 as subsequently amended (vide *Burma Forest Manual*). Under this Circular, to which the student should refer, instead of free exercise of rights the right-holders have to state their needs to the Divisional Forest Officer who then causes the trees to be marked for them and these trees only may be felled and extracted.

21. Should it be necessary to close any area to right-holders for reproductive or other purposes the Local Government may do so ; in this case some other convenient area will be made available.

22. In at least one case in Lower Burma extraction of bamboos by right-holders has proved so difficult to supervise that the forests have been thrown open to *any one* for a fixed period, one or two months, and at other times of the year bamboos must be paid for whether by right-holders or others.

23. Rights to grazing should state the number of heads of particular kinds of animals allowed in order that these may be checked. Also because the grazing of goats is for example more harmful than that of cattle and the latter probably less harmful, per individual, than that of buffaloes. The ticket system of licensing grazing referred to under Forest Offences is useful since the vendors being local people are well aware of the circumstances should non-right-holders attempt to pass off their cattle, etc., as belonging to right-holders, or should right-holders exceed the numbers for which they have the right of free grazing. As a method of direct protection pounds may be built and animals grazing illicitly put into them.

24. *Rights and Privileges.*—Strictly speaking there should be a distinction between "rights" and "privileges" but in practice there has usually been little save in the case of *taungya* cutting which is referred to in the next chapter. All rights and privileges are subject to revision and control by the Local Government though "rights" cannot be abolished except when they are not claimed at the time of notification of the Reserve or as an additional punishment in the case of a fire in a Reserve caused wilfully or by gross negligence by right-holders.

A recent circular of the Government of Burma points out that when a forest is so burdened with rights that it will have to be managed in the interests of the right-holders there is no reason why they should not pay the expenses of protection and management. Though the "right" to forest produce is ordinarily free of charge the Local Government can, and does, make a charge in cases where this is justified. Provision for extraction at royalty rates is suggested by Government as a convenient method of dealing with claims by villages some distance away when the rights to be granted to the nearer ones are heavy. When the object is to protect the forest as a source of domestic supplies this method is especially suitable. Claims to forest produce the enjoyment of which has not extended over five years do not receive the same consideration as claims based on a longer period of use and where the pressure of rights is considerable these claims may be relegated to the position of a privilege, subject to payment. These recent orders do to some extent draw a distinction between "rights" and "privileges." One of the greatest difficulties connected with this subject is the fact that right-holders mainly require posts and poles of small sizes for it is the removal of immature stock that makes proper management more difficult. No effort should be spared in educating right-holders up to a sense of their responsibilities and in pointing out to them that it is in their own interest to aid in the protection of the forest.

Indeed it may be confidently stated that efficient prevention against all kinds of offences and abuses is only possible with the co-operation of the local people. Every forest officer should therefore do his best to become acquainted with and to gain the confidence of the inhabitants in his jurisdiction so that he may gradually lead them to see that preservation of the forest is for their own benefit and get their willing assistance to this end.

CHAPTER VI.

"TAUNGYA" CUTTING.

25. This practice cannot be claimed as a right. In the words of the Local Government, "It is merely a privilege which can, at the time of reservation, be controlled, or restricted in any way, or abolished without payment of compensation by Government." When a reserve is being settled if it is decided that *taungya* cannot be abolished the Settlement Officer should consider whether there is not sufficient land outside the reserve still available; if so the reserve may be kept free of any burden of this kind. On the other hand the *taungya* cutter when under control of the Forest Officer is a very useful—almost indispensable—person when it is desired to regenerate by means of plantations. It may therefore be very desirable to retain any *taungya* cutters there may be on the area and to allow them to continue their hereditary occupation *under control*. This is usually done by the constitution of Forest Villages, rules for which will be found at the end of Burma Forest Manual. Forest Villages cannot be constituted until after reservation is completed.

26. *Effect of "Taungyas."*—In the "*taungya*" system of agriculture the forest is cut down, allowed to dry and then burnt just at the end of the hot weather. The burning not only provides manure in the form of ashes but kills many of the stumps and weeds which would otherwise interfere with the crop, which is sown when the rains begin. The fire also kills large numbers of bacteria in the soil. These are of two kinds, some which fix nitrogen from the air in the soil and make it available for plant food ; others live on nitrogen fixing bacteria The second class are much more affected by the fire than the former, therefore after a fire the useful ones are able to increase vastly so that the supplies of nitrogenous foods are temporarily increased. There is therefore a much better growth than usual in the first year after the fire. For a large part of the hot weather however the soil is exposed to sun and drought and for some time afterwards, depending on circumstances, the soil is deprived of its cooling, moisture-preserving, humus-providing canopy. The crop which is taken from the area also removes considerable quantities of plant foods since agricultural crops make a much more heavy demand on the soil than forest crops. The soil of a *taungya* area is thus impoverished and if too frequently cut over will become almost unproductive. The natural crop of forest species which springs up after a *taungya* is known as *ponzo* and consists as a rule of soft-wooded useless species, together with grass, *bizat* and creepers of all kinds. Sometimes the final result is absolutely pure bamboo from which all tree growth has been eliminated. In other cases valuable species such as teak and *pyinkado* do gradually reintroduce themselves but in any case the value of the forest is depreciated for long periods, even extending to centuries, before anything like the original crop is re-established. The exposure of the soil to torrential rains may have serious results especially when the soil is loose and on steep slopes. Under these conditions the soil is washed away into the streams and carried down into the plains where it may cause silting up of the water courses and be spread over valuable agricultural land with disastrous results. On the steeper hillsides the washing away of the soil leads to land slips and exposure of bare rock on which nothing can grow. The headwaters of streams to be used for irrigation are therefore usually reserved as are the forests along the alignment of hill cart roads or railways in order that any *taungya* cutters may be controlled, or prohibited if necessary, so as to prevent silting or land slips.

27. The possibility of the earth being washed away is greatly reduced if the cut area be rapidly restocked and the soil once more covered. Also the fertility of the area is better preserved if quickly covered again. Rapid recovery generally takes place if the *taungya* is cut in virgin forest or at any rate if it has not been recently cut over. Consequently less harm is done if sufficient area is available to provide for a long rotation of say 30 or 40 years at least. If less not only are very poor crops obtained but the recovery is slower with greater danger of erosion of the soil.

28. When circumstances permit *taungya* cutters can sometimes be induced to give up the practice by provision of suitable land for permanent cultivation, and possibly advances to buy plough cattle. Terracing of hillsides and subsequent irrigation which is practised in the Shan States, Karenni and in parts of Upper Burma is a possible solution if the people could only be educated up to it, but the ignorance and almost fanatical prejudice against any change of the backward people who live by shifting cultivation is usually a stumbling block. It is also unfortunately true that when hill men, who are the worst offenders in this respect, are brought to the plains they rapidly degenerate both physically and morally. It is therefore better to let them continue their ways *under control* and to insist on the replanting of their *taungya* with useful and valuable trees. As Forest Villagers they are provided with regular work under a headman appointed by the Forest Department and also receive other benefits such as remission of certain taxation, free forest produce, etc., in return for planting and weeding the trees put out in their *taungya*. They thus become very useful members of society and though there may sometimes be differences of opinion as regards the value of *taungya* plantations compared with natural forests there can hardly be any question as to the desirability of turning the destructive habits of inveterate *taungya* cutters to account in the way just described.

CHAPTER VII.

FIRE-PROTECTION.

29. The term is not a good one but has come into common use to describe all the operations intended to prevent fires in forests and to control them when they occur.

The cause of fire is nearly always Man and may be accidental or wilful though fires may also conceivably be started by natural means such at lightning. It has been suggested that friction between two bamboos, due to wind moving them, may cause fire and this is possible, but anyone who has tried to ignite a piece of bamboo in this way will probably find it hard to accept this accident as a frequent cause of fire. The usual causes are spread of *taungya* fires, burning of village grazing grounds to stimulate new grass, wilful firing in order to drive out game or with intent to do damage out of ill-will, carelessness in connection with smoking, camp fires, etc., etc. Once started, in the dry season, the fires spread assisted by wind and frequently cross badly maintained fire lines or get over good ones by means of sparks blown by the wind. These causes are so common that unless special steps are taken to protect them practically all forests of dry enough nature to burn, get burnt every year in Burma—sometimes several times in the season.

30. *Effects of Forest Fires.*—There is perhaps no subject in the history of Forestry in Burma which has been so hotly debated and it is consequently not easy to make hard and fast statements on this question which will be acceptable to all. The more controversial side will however be considered under Silviculture where the effect of fire and fire protection on individual species and crops will be discussed in detail. Under the head of Protection it is necessary to treat with *general* effects of fire and to indicate only the directions in which the facts are in dispute or perhaps not fully understood. It may be stated as a generally accepted fact that fire must necessarily do harm to a tree and that any tree would live and flourish better, *as an individual*, without fire. This is due to the fact that fire scorches and withers the leaves and may even consume some part, or all, of the tree. At the least it scorches the bark of adults and kills down seedlings and saplings to the ground though the stumps and roots may still survive. If the ground fire is very hot the roots may be injured and the fertility of the soil is always injured by the destruction of humus while further production of it for the year is prevented since the fallen leaves, twigs, branches, etc., are all consumed. Many seeds are destroyed thus lessening the chances of regeneration. Stems which are continually burnt become distorted and charred, with the final result that decay enters the wounds and renders the wood useless. Many hollows in trees arise in this way. Dead and fallen trees may be totally consumed with

considerable loss of material which might have been profitably extracted as timber or fuel. Consumption by fire of logs or other manufactured forest produce comes in rather a different category of damage and the harm is so obvious that it need not be mentioned again.

31. Indirect damage of a serious nature is due to the effect of fire on the physical nature of the soil. By consumption of the humus and burning back of the undergrowth fires render the soil more liable to erosion by heavy rains and drip from trees, with consequent exposure of the roots and excessive quantities of silt in the streams which may give trouble in the lower reaches. The harder layers of soil left do not absorb the rainfall so well with the result that floods become more frequent and of greater severity. On the other hand it must be pointed out that as the more valuable forests in Burma contain many different species of trees some of which are more resistant to fire than others the use of fire may result in an increase of the resistant species. Teak is one of the most resistant and it is around the effect of fire on teak forests that most of the controversy has raged. Those who consider fire beneficial *on the whole* do not however suggest there is no damage to individual teak trees but they advocate fire because the ultimate result, according to them, is better than if there were no fire at all. The question is mainly one of regeneration and all opinions now accept as proven the fact that protection increases the undergrowth, favours fire-tender species and soil conditions which are unfavourable to the germination of teak seeds thus generally bringing about a diminution in the percentage of teak. This is a very serious result. On the other hand fire destroys many of the weeds and leaves exposed the mineral soil which is most favourable for germination of teak. Teak seeds are very resistant to fire, and even if repeatedly burnt back teak seedlings spring up again from the roots till they finally grow large enough to escape being burnt back. Teak regeneration is thus favoured by fire as compared with most other species. In any case Protection costs a lot of money and is difficult to make successful hence there is basis for argument as to whether the cost and trouble involved by protection is financially worth while. The damage is usually difficult to assess in terms of money as it may not be apparent at the time but there may be cases in easily accessible forests in which the value of timber and firewood destroyed is alone more than the cost of protection. Under such circumstances protection is obviously indicated.

32. The arguments for and against fire-protection are well summarized by the Working Plans Officer (Mr. Barrington), in the Working Plan for North Toungoo Division, who states that most forest officers are agreed on the following points :—

(*a*) Fire-protection encourages bamboo undergrowth at the expense of tree seedlings.

(*b*) It encourages weeds and shade bearing tree species at the expense of light demanders such as teak.

(*c*) The timber destroyed and growth retarded in natural forests as the result of fires cannot justify the annual expenditure of Rs. 40 per square mile necessary to protect them, far less the concentration of the executive staff on fire-protection for a quarter of the year.

(*d*) Plantations should be protected as long as fires would harm them, and large blocks are sufficiently valuable to justify indefinite protection if it can be shown that the growth of the trees is seriously affected by fires.

(*e*) Damage by fire in an area protected for a series of years is so serious that artificial "early burning" is likely to be less injurious than inefficient protection.

These remarks must be held to apply with particular force to teak forests. The last one is by no means generally accepted.

33. *Necessity of Protection for Dry Forest.*—The drier the forest the hotter will be the fire since all the material is more combustible and generally there is more of it owing to the more open nature of the tree growth. Grass and herbaceous plants are more common and when dry these add to the flames. In fact in a dry forest which is regularly burnt a kind of vicious circle is set up. First the open nature and dry material causes a hot fire which in its turn causes the forest to become more open, decreases the fertility of the soil and the vitality of the trees thus rendering them more and more liable to damage as time goes on. The final result is often that very few species can survive and the forest may tend to become gregarious. The case of "In" forest is an example though it is not suggested that fire is the sole cause of the gregariousness.

Burma Forest Manual. Departmental Instructions for Forest Officers in Burma—129—132. Standing Orders for Subordinates, 142—159.

34. *Method of Fire-protection.*—The details of the method of the protection against fire are laid down by the orders of the Local Government and the Chief Conservator of Forests. To avoid

repetition they are not given here but the student should not leave the subject till he has thoroughly mastered the orders in full. *To be of any use fire-protection must be successful* and this entails great care on the part of everyone concerned.

35. The direct method of protection is by means of fire lines, both internal and external, consisting of tracks, usually five feet wide, permanently and completely cleared of forest growth and kept swept throughout the fire season by regular patrols. Outside the fire line is a *Trace* usually fifteen feet wide (ten feet on the interior lines) on which all the vegetation is cut back and burnt, and a *Safety Strip* to the outside of the trace on which the growth is burnt back (without in this case any cutting or felling). This safety strip is 300 to 400 yards wide in any case but as most unclassed forests are burnt annually in Burma it is not usual to place any limit on the width of the strip. The detailed orders deal mostly with the precautions to be taken by the staff when preparing the lines since fires frequently occur owing to careless burning of the traces and safety strips.

36. Special care is necessary when the area to be protected is a Regeneration Area because of the heavy weed growth usually found in young plantations which makes the fire, if any, very fierce and difficult to control. Also there are generally older plantations around the young ones in which special danger would occur. As a matter of fact a great many fires are caused by careless burning of the *taungya* of the year. When it is intended to fire a safety strip at least seven days' notice must be given to timber traders who have logs in the neighbourhood and to local *taungya* cutters, the premature burning of whose *taungyas* might cause distress. Since careless burning of material on the fire lines and burning back of the safety strip so easily results in fire entering the protected area the Range Officer is held personally responsible for this work and must supervise it himself. Such burning must be done when there is no wind blowing and in the evening when the flight of sparks and glowing logs, etc., are easily visible.

37. Indirect protection is afforded by interesting the villagers in the neighbourhood and by gaining their goodwill and co-operation. Under the Forest Act all right-holders, lessees, contractors and any persons in Government Service living in a village contiguous to a reserve are bound to report fires, to assist in extinguishing fire and to prevent fire from outside entering a protected reserve. They are also bound to prevent other persons causing fires and to assist in detection

of offenders. If a fire is wilfully or by gross negligence caused by a right-holder the Local Government may cancel all or any of the rights or privileges in the forest concerned. The goodwill of villagers may sometimes be gained by free grants of produce to communities who have either given assistance in extinguishing fire or who have prevented others from causing it.

38. *Extinguishing Fires.*—When fire occurs prompt measures must be taken to put it out as soon as possible ; if necessary villagers being employed to help the staff of fire-watchers and subordinates in charge. The fire may be stopped by surrounding it with men who beat down the flames with green branches, etc. This is only possible in the case of a light ground fire. In more serious cases it may be confined to a limited area by clearing temporary lines on which watchers wait to prevent the fire crossing. At other times all that can be done is to prevent it crossing interior lines by means of burning back from them. Advantage should always be taken of natural obstacles such as streams, roads or paths, etc.

39. *Fire Reports.*—On the occurrence of a fire a report giving the particulars must be promptly submitted. It should give date and time of occurrence, date and time the Range Officer and Beat Officer arrived on the spot, cause of fire if ascertained and details of the persons by whom it was extinguished. A map showing the burnt area is attached to the report. For more detailed instructions reference must be made to the Standing Orders on the subject.

40. *Early Burning.*—As stated in a previous paragraph early burning has been suggested as a substitute for fire-protection, the idea being that a light leaf fire early in the season prevents heavy accumulation of material which would cause a much fiercer fire later on. On the other hand some officers hold that whereas a comparatively hot *rapid* fire during the leafless season when the trees are resting may do but little harm, a light fire *which passes slowly* through the area while the cambium is active is likely to do much more damage. Further research is obviously required. In the meantime the attitude of those in authority is summed up in the following orders :—

> " Reserved forests which are not protected from fire may in some cases benefit from early and repeated burning. This is likely to be particularly useful against certain forms of insect attack and may serve to protect fallen timber. Results should be carefully watched in each case, as premature fires may have an adverse effect on the undergrowth and even on the soil. When early burning has been ordered it should

be carried out carefully and systematically; it is by no means easy and has often degenerated into late and severe fires."

41. *Effect of Continuous Protection.*—In dry forest with a low rainfall there seems little doubt that protection is beneficial. By freeing the forest from continual burning a better growth is encouraged—the soil becoming more moist through not being burnt and because there is more undergrowth to protect it from sun and wind. In consequence the erosion of surface soil by rain is lessened, the water is retained longer in the soil and so eventually the most favourable conditions are reached. On the other hand after some years of successful protection the danger from an accidental fire is much increased owing to the larger amount of inflammable material on the ground and if this material eventually gets on fire the fiercer heat does more damage to the forest growth than in the case of an annual fire.

42. In moist forest, which includes a great deal of the most productive teak forests in Burma, the effect of Protection is much the same as in dry forest, *viz.*, a larger amount of undergrowth including bamboos, a moister soil with more humus, better conservation of the water supply and better increment on the growing trees. Moist forest however contains many species which are fire-tender and protection gives a fillip to their development and an increase in their proportion of the total growing stock. Conditions for the germination of teak are less favourable and in course of time the forest tends to produce less teak and more of other less valuable species. The effect is more marked in moist forest which is approaching the evergreen type. Here it has been observed that the evergreen forest spreads under the influence of protection and teak forest changes gradually, *via* pyinkado, into evergreen which contains little or no teak.

43. Species which normally occur in dry forest sometimes grow very well where there is a much higher rainfall. For example *in* grows in some of the wet zones of Upper Burma. Fire-protection in such an *in* forest tends to kill it out rapidly, the *in* being replaced by evergreen species including oaks. A similar result has been noted in "sal" forests (a species very much like *in* in many ways) in Bengal where "sal" was found to be in danger of extermination by fire-protection. Hence while it is still true that the soil is improved by protection the *value of the crop is lessened.*

44. From the above it will be seen that the desirability of fire-protection is a matter which has to be considered for

each separate area or block of forest. The financial aspect should be carefully considered for each block and this as laid down in " Departmental Instructions " should " *ordinarily form the main criterion by which a policy of fire-protection would be justified.*"

CHAPTER VIII.

PROTECTION OF FAUNA.

45. Forests are the natural home of wild creatures of all kinds. Indeed until comparatively recent years in some countries forests were regarded mainly as a home for game and their value as timber producers was looked upon as quite a secondary consideration. Even to this day there are forests set aside and managed solely with a view to the preservation of wild animals, including birds, which owing to the increase of population and cultivation would otherwise be exterminated. At the time when Burma was more or less covered with forests and the population was very scanty wild animals roamed all over the country (a tiger was found and killed on the steps of the Shwe Dagòn Pagoda in Rangoon only a few years ago) without any serious inconvenience or interference from man. As towns and villages sprang up, cultivation spread and cattle multiplied the game was driven further and further into the deeper jungle ; partly because wild life is timid and partly because it became the prey of man and more and more hunters who were armed with weapons of ever increasing efficiency. The same sequence of events has happened all over the world with the result that many animals have been exterminated. For example in Western Europe wolves no longer exist and deer with very few exceptions are only found in Parks or deer forests in which they are carefully preserved. The Bison in North America were almost exterminated when the Government stepped in and preserved a number of them in the famous Yellowstone Park. In Britain there are a few wild pheasants but the majority are preserved, in privately owned woodlands, by private owners who can afford to do this for their own sport in the shooting season. Even though the birds are private property it is illegal to shoot them save in the authorised season.

46. In Burma we are in a transition stage. Game exists in nearly every piece of forest, but it is rapidly being driven

away far from the haunts of men. Even in the remotest jungles certain animals whose marketable value is high are being pursued and killed in season and out of season by professional hunters (or rather *poachers* since they rarely have game licenses).

47. In the following chapters we shall see that the presence of wild animals may be beneficial to forestry in some cases, while the most destructive of them do so little damage comparatively that their presence is not incompatible with scientific management. From the strictly practical and financial point of view therefore it is plainly wrong to destroy them wholesale, or even to kill single ones needlessly. This is especially the case with the larger mammals, elephants, bison, saing and rhinoceros which are so often destroyed for the sake of a few viss of ivory or flesh. On the other hand, the Buddhist, the Naturalist and the collector of sporting trophies, each for his own special reasons, all deplore the wholesale killing of wild animals.

48. One of the first instincts of primitive man was to hunt and this led him to encounters with wild and ferocious animals armed, as he very often was, with poor and ineffective weapons. The hunter therefore developed a sturdy, self-reliant character and possessed endurance, skill and courage to a marked degree. Fortunately the instinct has survived in civilized man who still finds healthy and character-building exercise in the chase. Virile races will always have this instinct and its indulgence in a civilized fashion is desirable. The sportsman, however, does not kill for the lust of killing or for monetary gain and he would scorn to take life in an unsportsmanlike fashion ; as for example shooting a bison over a " salt lick." He shoots because he enjoys pitting his skill in tracking, endurance in following and courage in facing a wild animal against the defensive instincts of the quarry. Success gives him a trophy to be kept in memory of a hard, eventful and exciting chase. If the animal he has hunted proves to be a female or immature it is allowed to go free ; in other words, he shoots with discrimination, while the killing of old mature males, whose loss makes no difference to the future breeding of the herds, merely anticipates their removal by death and replacement by younger males.

49. Legal protection for game in Burma is afforded by the Burma Game Rules which are made under the authority of the Burma Forest Act. These rules are at the moment

of writing in process of being remodelled, but the following are the main features which are not likely to be altered materially. First the Local Government declares certain animals to be "protected animals." These include—

(*a*) the elephant, rhinoceros, tapir, buffalo, *mythun*, bison, *saing*, *serow*, *gooral*, and Argus pheasant wherever found.

(*b*) "Thamin" and hog deer *inside reserved forests and sanctuaries*.

(*c*) Any animals in addition to the above for which a close season is prescribed under the Wild Birds and Animals Protection Act *during such close season*.

Unprotected animals include all animals other than "protected animals."

50. Power is taken to declare any animal to be a "protected animal" in respect of the whole or any part of Burma and to declare any area to be a sanctuary for the preservation of animals.

51. Apart from special restrictions the following acts are generally prohibited :—

(*a*) Shooting any animal with poisoned arrows.

(*b*) Laying down poison for any animal.

(*c*) Netting wild water birds.

(*d*) Hunting any animal by means of pit-falls.

(*e*) Hunting within 100 yards of the compound of a Buddhist monastery.

(*f*) Hunting animals during a close season.

(*g*) Building a platform or *machan* or using artificial light, for the purpose of hunting any animal other than carnivora.

(*h*) Shooting any animal other than carnivora from the back of an elephant or from any kind of vehicle.

52. Subject to exception in favour of persons—

(*a*) killing or wounding animals in defence of man or *bonâ fide* defence of property ;

(*b*) destroying any individual wild elephant which has been prescribed by the Deputy Commissioner ;

(*c* destroying carnivora which have been preying on man or domestic animals;

(*d*) hunting wild dogs

no person may hunt "protected animals" anywhere, or any animal whatsoever in a reserve or a sanctuary save in accordance with the conditions of a license issued by the Forest Department. Even persons exempted from the necessity of a license under (*a*) (*b*) (*c*) (*d*) of this paragraph may not follow an animal into a reserved forest except with the written permission of a Forest Officer which is valid for the day of issue only. Tusks of elephants killed under this exception must be handed over to the Forest Department unless the circumstances are such that the Conservator of Forests sanctions their retention by the hunter.

53. Without a license a person may hunt unprotected game in public forest land provided this is not a sanctuary.

54. The license limits the number of animals that may be shot to two bison, two saing, two serow and two gooral and these must be males with horns of a size not less than the minima prescribed in the license. Licenses to hunt rhinoceros, tapir, buffalo, mythun and argus pheasant are only granted for scientific purposes. Elephants may only be killed and caught under the conditions of a special license.

55. Students should make themselves acquainted with all the rules, the details of which are collected in a handy form in the Burma Game Rules Manual. The account above—although only a very short summary—shows that adequate legal protection already exists. It is regrettable that owing to lack of interest and sometimes wilful disregard the rules are not strictly enforced. It is admittedly somewhat difficult at times to prevent unlicensed hunters from shooting in reserves into which they penetrate from adjoining unclassed forests while evidence of offences is often withheld by villagers in return for bribes of meat, etc., but at least every forest officer down to the humblest subordinate can set an example by observing the rules strictly and reporting every offence which comes to his knowledge. Though the truth may be unpalatable it is unfortunately the fact that subordinate forest officers are often among the worst offenders as they lend out their guns illegally and connive at breaches of the law. Range Officers must remember that their duties include the protection of wild animals. Subordinates who have private or Government guns should only be allowed, except in self-protection and on pain of losing the privilege, to shoot pig, deer and carnivora. It should be remembered in this connection *that there is very little real danger from wild animals and a man who is always shooting them on this pretext should be suspected.* The issue of game licenses is at the discretion of the Divisional Forest Officer and it should be used to prevent unscrupulous or undesirable characters from getting them either in his own or adjoining

divisions. They are also enjoined to object to licenses for shooting elephants by hunters merely for the sake of the value of the tusks and meat.

56. Fishing in Reserves is prohibited save under license. Poisoning and dynamiting water is prohibited as these practices are exceptionally destructive to fish of all sizes, more especially the small ones on which the future supply depends. Since fish generally thrive best in shaded streams, power is provided in the Forest Act whereby the Deputy Commissioner can prohibit the felling of trees within any distance not exceeding 66 yards from the bank of a river or fishery. Although fisheries generally are under the management of another department forest officers should assist with advice or information in any case which may come to their knowledge and do all they can to preserve these useful animals, whether in Reserves or not.

CHAPTER IX.

CONCLUSION.

57. Before concluding this section on the Protection of Forests from Man it is desirable to stress once more the remarks which have been made under several heads about getting the co-operation of villagers in the neighbourhood of forests. Broadly speaking, methods of protection based solely on purely defensive and direct methods are almost bound to fail, partly if not entirely. The most successful methods depend on having the local population on the side of law and order, willing to assist in protective measures and in handing over offenders. To get this goodwill involves personal touch as much as possible, education in the aims and objects to be attained, generous treatment of helpful communities in the way of free grants as personal rewards, provision of necessary produce at reasonable rates, just and fair treatment of villagers and stern correction of any case of oppression by subordinate officers. Such methods combined with firm dealing with offenders are bound in time to improve matters which it must be confessed are somewhat serious in many divisions at the present day.

PART II.

Protection against Mammals, Birds, Insects, etc.

CHAPTER X.

PROTECTION AGAINST MAMMALS.

58. Mammals, birds and insects make up a large proportion of the animal kingdom which it is convenient to divide into—

(i) *Vertebrates*, which have a backbone.
(ii) *Invertebrates*, which have no backbone.

Vertebrates include—

(*a*) *mammals*, hairy animals, with warm blood, which give birth to their young alive and suckle them ;
(*b*) *birds*, which have feathers, can usually fly, and lay eggs from which their young are hatched ;
(*c*) *reptiles* which are covered with scales, are cold-blooded and lay eggs. They are often amphibious;
(*d*) *fish*, which are cold blooded, live in water and breathe through gills. Their young are usually hatched from eggs, or spawn as it is called in this case.

59. Though interesting to us as Forest Officers fish may be dismissed from this study as they exert no influence one way or the other on the forest. Similarly reptiles are not of sufficient importance to warrant further mention but mammals and birds will have to be considered in some detail.

60. A certain amount of damage is done to forests by the mammals named below which live wholly or in part on green or vegetable foods since they actually consume parts of the forest growth. As a general rule however the damage is not really serious. As regards wild animals, except in regeneration areas, the incidence of grazing for example is so small owing to the enormous areas and comparatively small numbers of game that it may be disregarded.

61. *Elephants.*—The animal which consumes by far the greatest amount per head is the elephant, but it is also a very valuable animal. When caught and tamed it is well worth the value of the food it eats, except under special circumstances. Elephants not only eat large quantities of bamboos, grass, climbers and tender shoots and branches but with their enormous bulk and heavy weight they bend over and trample down more than they actually swallow. They tread down seedlings, bend and break off saplings and poles, often it would seem for the mere pleasure of doing so as the broken off pieces are often thrown aside without being eaten. Their fondness for succulent creepers also leads them to bend over or destroy pliant stems or break off branches accidentally while pulling down their favourite morsels. The devastated appearance of a bamboo forest through which elephants have passed while feeding must be seen to be believed and it has been stated that the greatest harm elephants do is in the wasteful destruction of bamboos which form such a large proportion of their diet. This might be the case in a forest managed for the production of bamboos *but in a teak forest in Burma* it is emphatically not the case for coupled with fire to burn the smashed bamboos great good results from this opening up of the cover. Regeneration of teak is given such useful assistance that nobody need grudge a herd of wild elephants a few hundred thousands of bamboos in a teak forest (provided it is not an accessible area from which trade extraction of bamboos takes place). Wild elephants prefer the distant recesses of the jungle as a rule, and they usually stay in the less valuable evergreen forest where it is cool and there is plenty of water. During the rains, especially towards the end of the season when the paddy is old enough to be tempting, and just before harvest, wild elephants often descend to the more accessible forests and raid the paddy-fields and *taungyas*. Then they do enormous damage and the only protection is to frighten them away by fires or by shooting them.

62. During the hot weather elephants sometimes strip off the succulent bark of young trees and may do a lot of harm to a teak plantation in this way. Wild animals, however, are less likely to do this than tame ones which cannot roam further afield to find more natural food and are more often in the locality of plantations at the driest season.

63. Wild elephants have a curious dislike of such things as boundary posts, or even bungalows, in some cases and throw them or push them down. In the case of boundary

posts likely to be annoying to them (or used as scratching posts) it is usual to leave only a short piece projecting from the ground and to wrap it with barbed wire or stud it with projecting nails. Buildings can be protected from elephants by a deep wide trench dug round them.

64. Domesticated elephants do the same kind of damage as wild ones, but it can be checked by prohibiting their owners from letting them loose to graze except in suitable spots, *i.e.*, not near young plantations, *taungyas* or field crops. So long as they can find *kaing* grass or bamboo forest they are usually content not to stray very far away and they should be loosed accordingly. They should not be set free in or near plantations owing to their habit of peeling trees and damaging them by leaning against them to rub their skins, etc.

65. The number of wild elephants is kept down and the herds driven into the more remote forests, where they do no harm worth mentioning, by the organization of "Kheddahs" and since the supply of animals is not equal to the demand by timber working contractors the appearance of elephants in large numbers soon brings on the scene someone anxious to catch them. On the whole then elephants are a distinct asset to our forests ; without them it would be impossible to extract much of the timber now brought out with their assistance.

66. *Domestic Buffaloes and Cattle.*—The presence of these animals in or near forests is generally unavoidable and though they may be harmful they must be allowed so long as the damage is kept within limits and their grazing controlled. Buffaloes are more harmful than cattle owing to their larger size and appetite and their habit of never walking round but through and over young growth. They, as well as cattle, graze on young shoots and seedlings and tread down the latter. Provided grass is available however they prefer it and leave other things alone especially if the grass is found along streams where they like to spend their time. In regeneration areas where grass and weeds are usually plentiful, there is ideal grazing, but needless to say this is just the place where it cannot be permitted and all animals should be kept out as far as possible. In nurseries also intruders are unwelcome and nurseries are usually fenced as a matter of routine in all cases where there is any danger from cattle, etc. Cattle are sometimes the indirect cause of forest fires which are either carelessly started by herdsmen, or deliberately to bring up a new crop of grass. On the whole, however, there is

usually plenty of grazing ground in Burma outside the forests proper and animals only go inside during short periods of the year as they find more grass in the open grazing grounds outside. They are considered useful in cutch plantations pulling down annual climbers which would otherwise be left owing to thorns which make the work of cutting them too difficult.

67. The Report on Forest Administration in Burma for the year 1925-26 called attention to the fact that grazing and cattle trespass in reserved forests is becoming more and more important not merely on account of damage done but because it " is a main factor in introducing disease into the forest which affects both the wild life in the forests and the domestic stock employed on extraction and transport." The point is an important one.

68. During the forest year 1925-26 buffaloes and cattle to the number of 544,600 grazed in reserves but out of these about 495,000 did so by right under Settlement. This shows that practically all the grazing which takes place is unavoidable. The value of this free grazing if charged for at full rates would have been well over 1½ lakhs of rupees. These figures are probably by no means accurate but they give an idea of the value of the concession to the people. The business is on an infinitely grander scale in India proper, for in 1922-23 the total Forest Revenue from grass and grazing there amounted to no less than 72 lakhs of rupees. In this country it is unnecessary as a rule to take any special precautions, but in India strict measures of control have to be arranged. All that is necessary as a rule in Burma is to protect all areas under regeneration till the trees are big enough to be out of harm's way, to limit the numbers to a figure which the forest can support, and to make adequate arrangements for collecting fees. In and around Maymyo and at one or two places along the railway lines near Rangoon the number of cattle has grown so much as to constitute a nuisance and danger to forests nearby these centres of milk production. Sooner or later it will probably be necessary to take some action to improve matters, but these are isolated cases and do not affect the general question. As to what area per head should be allowed as a safe figure it would seem from experience in other countries that about three acres per head of cattle and four per head of buffalo is enough.* If less than this is available it would be

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* In the latest orders to Forest Settlement Officers the Government of Burma has laid down that not more than one head of cattle should be allowed to each three acres of forest allotted as pasture for right-holders in a reserve.

advisable to close parts of the area for some months in the year; in rotation, if complete closure is impossible. Cattle should of course be in charge of a herdsman when loosed to graze.

69. Although the subject is only indirectly connected with this heading it may be stated here that in a few places grass is cut and made into hay for fodder. If a regular supply of hay is necessary it is not advisable to cut over any particular area every year continuously. The grass should occasionally either be cut *after seeding* (when its value as hay is minimised) or allowed to stand uncut.

70. *Goats and Sheep.*—Of all animals goats are the most destructive as they will eat almost anything and even stand on their hind legs to reach and pull down saplings. Shoots grazed by them are crushed off and new shoots do not grow so easily as after the clean-cut bite of other animals. Fortunately, however, there are very few of them in Burma except in the dry zone scrub areas where the forest is not reserved and is of little value for anything else. Sheep are also only found in these dry districts, *e.g.*, Meiktila, Mônywa and Mandalay. Their effect on valuable forest is therefore nil. The statistics of goats imported into Rangoon by train however show a very large increase in the last few years so that it is obvious breeding flocks of them are increasing in Burma and it may one day be necessary even to legislate against them if they spread into well forested districts. In many European countries goat grazing is prohibited by law owing to its exceptionally harmful nature.

71. *Wild Buffalo, Bison, Mythun, "Saing" and Wild Goats.*—These animals are so comparatively few in number that the harm they do in devouring forest growth is negligible. If they ever stray into plantations, etc., their fear of man renders it quite easy to frighten them away to their more usual haunts.

72. Deer, sambhur, *thamin*, barking deer and hog-deer are widely distributed even in quite well-frequented areas and they are much more inclined than the large mammals to give trouble in and around plantations and nurseries. They graze on seedlings and tender shoots and tread them down in their search for grass, leaves and fruits on the ground. Sambhur and barking deer are often a nuisance in regeneration areas and it may be necessary to shoot them freely. Sambhur are said to be particularly fond of the shoots of young *yemane* trees and deer as a class have a habit of rubbing their horns up and down the stems of saplings and poles, bruising or tearing up the bark with

their teeth and thus exposing the tree to danger from fungi and insects, or even killing it. They eat a good many fruits too, especially pulpy ones, but the damage done is probably discounted by the fact that they drop the seeds afterwards at intervals and thus help to distribute them over the ground. Nurseries and crops of rice in *taungyas* are very frequently fenced as a protection against deer.

73. *Pigs.*—These animals on the whole are useful and to be encourged except for their bad habit of raiding crops of *taungya* rice just before the latter is ready for reaping. They eat up seeds, root up young seedlings and bite through stems and roots. On the other hand, they grub up the soil over large patches and facilitate the germination of seeds especially those which, like teak for example, germinate best in contact with the bare mineral soil. Among the leaves and in the soil they find and eat or otherwise destroy many larvae and pupae of harmful caterpillars, moths, beetles, etc., which would otherwise do a great deal of damage. Even those too small to interest the palate of the pig are turned up out of the soil to become the prey of birds and smaller animals. While pigs therefore are generally considered to do no harm to speak of, in teak forests they are undoubtedly very useful on the whole.

74. *Porcupines, Hares, Rats and other Rodents.*—These animals have sharp incisor teeth with which they are continually cutting into bark, roots and even the wood of trees. Porcupines are said to be especially addicted to the destruction of cutch seedlings by cutting them off. Rodents also consume large quantities of seeds, and rats are so fond of bamboo seeds that the widespread seeding of bamboos may induce a regular plague of them in the neighbourhood. This sometimes results in famine and is followed by epidemics and disease since the number of rats increases to such enormous proportions that the sowing of field crops becomes impossible. The people are brought to a state of starvation and fall victims to disease.

These rodents are most troublesome when they invade *taungyas* or nurseries where rats and mole-rats burrow under the seedlings and turn them up. If they do this they have to be shot, poisoned, trapped or hunted by cats and dogs.

Snakes should not be killed indiscriminately. The great majority feed on the smaller rodents and are the best means of controlling them.

75. *Bears, Monkeys and Squirrels.*—Bears are often supposed to do considerable damage, but this is probably

exaggerated. The large holes made by them to extract honey merely open out an already hollow tree. Monkeys and squirrels eat large numbers of flowers, succulent shoots and particularly nuts and fruits. In the latter case they destroy far more than they actually eat. In common with the bear however they spread the seeds of trees and also destroy large numbers of harmful insects or their grubs. Even at their worst it is neither practicable nor necessary to take any special precautions against them except in nurseries. They are specially destructive to *Thitya* and *Ingyin* which have been known to attract them in large numbers.

CHAPTER XI.

PROTECTION AGAINST BIRDS.

76. All birds which eat fruits or seeds and pluck off tender shoots necessarily do harm and this is increased by their habit of plucking large numbers of ripe and unripe seeds which they only partially devour. Many birds do this kind of thing and the damage to reproduction is increased when the birds come in flocks as is the case with parrots. Pigeons, hornbills and many other kinds are extremely fond of the fruits of the fig species (*nyaung)* and of the Loranthus (*kyibaung*) both of which are harmful plants, the former especially. They spread the seeds which owing to their sticky nature cling to their beaks, feathers and feet and are rubbed off on the bark of another tree later. The damage done in this way amounts to an enormous total as without birds the spread of the *nyaung* would be very much restricted. Fortunately most birds are insect eaters and even most of the others also live partly on insects so that the balance of usefulness is very largely in their favour. The birds which live mostly on the ground, such as jungle-fowl, pheasants, partridges and crow pheasants destroy untold numbers of grubs, caterpillars, white ants, etc., which live entirely or part of their existence in the soil. Other birds live on the insect pests of leaves, flowers, fruits and stems ; the wood peckers, for instance, picking out the larvae of the "bee-hole borer" in teak stems even at a considerable depth from the surface. These birds also have an uncanny habit of opening out the hole at the spot where their prey is to be found even if the latter's tunnel is several inches long. They have very long tongues which help them to extract

their catch. Birds of prey like the owl and hawks are very good in catching rats, mice and other harmful rodents even as large as hares.

77. By means of the Wild Birds and Animals Act protection is given to a large number of useful birds which may not be shot or trapped at any time during the whole year. Game birds including peafowl, pheasant, partridge, jungle fowl, woodcock, painted snipe, duck, teal, quail, plover and lapwing are only protected part of the year, *viz.*, during their respective breeding seasons.

78. In European countries birds are protected by law in the same way and in many places their breeding is encouraged by the provision of artificial nesting places. Among other suggested explanations for the higher incidence of attack by the hole borer in plantations as compared with natural forest, was one that removal of the virgin forest has done away with all old hollow trees, and other suitable nesting places, thus discouraging birds especially wood peckers which find no congenial surroundings and leave the vicinity of teak plantations. It was therefore suggested that nesting boxes should be provided. It would be interesting to know, if the suggestion has yet been carried out, and, if so, with any success or not.

CHAPTER XII.

THE INVERTEBRATES.

79. The second division of the animal kingdom, the *Invertebrata*, is divided up into sections, each of which is known as a phylum, these being again divided into classes, orders, families, genera and species.

The phyla of special interest in forestry are the *Arthropoda* (which is by far the largest) *Annelida* and *Mollusca*. We may dismiss the smaller phyla in a few words.

80. *Annelida* include the class *Oligochaeta*, or Earthworms, which are important since they burrow into the soil turning it over and over thus aerating it and rendering it more fertile. They also bury dead leaves and add to the humus and are therefore an important factor in maintaining the fertility of the soil. Darwin ascertained by actual experiment that earthworms bring to the surface from 15 to 18 tons of soil on the average per acre per annum.

81. *Mollusca* include certain slugs and shell fish which are important enough to warrant further mention later on.

82. *Arthropoda* are divided into—

(*a*) *Insecta* (Insects).
(*b*) *Crustacea* (Prawns, crabs, barnacles, etc.).
(*c*) *Arachnida* (Scorpions, spiders, mites, ticks, etc.).
(*d*) *Myriopoda* (Centipedes and millipedes).

83. Of these, *Crustacea*, *Arachnida* and *Myriopoda* have but little direct effect on forests though some of them do slight damage, for example, in the Delta forests crabs destroy seedlings, and some are useful in preying upon harmful insects, *e.g.*, spiders devour flies, aphids, etc.

From the above it will be seen that many animals such as spiders, ticks, etc., are not insects at all though commonly spoken of as such.

84. *Insecta* is a very numerous and important class as about 450,000 different species have already been described. Of these the largest number are beetles.

Although minute in size, as compared with mammals for instance, the damage done by the latter fades to insignificance when compared with the harm done by insects to forests and forest produce. For instance, careful estimates of the damage done in Burma by one insect alone, the "bee-hole borer" of teak, put it at 10 per cent. to 15 per cent. of the value of the total outturn and as the revenue received by Government from this source fluctuates round an average figure of about one crore of rupees it will be seen that the subject of insect damage is of immense importance. On the other hand, some insects are useful; for example the "Lac" insect, which produces an extremely valuable article of commerce, and the silkworm which provides us with silk.

85. A detailed definition of the characters which cause us to class an animal as an insect cannot be given in the scope of this book but it may be generally stated that insects are made up of (i) a Head carrying a mouth, eyes and antennæ (sensory organs), (ii) a Thorax which is attached behind the head, carrying three pairs of legs and also two pairs (in some cases one pair) of wings, and (iii) an Abdomen attached behind the thorax containing the digestive system or intestines and the reproductive organs. The adaptations of the three parts of the body and the organs attached to them are very numerous and varied according to the kind of life which any particular insect leads. For instance, insects which are predatory have legs adapted to catching and holding their prey while their mouths are provided with strong biting organs. Others bear legs so small and undeveloped as to be almost useless while mouths (or mouth parts)

may be almost non-existent. There is also great variety in the character of their wings.

86. *Life History of Insects.*—Before proceeding to details of various insects and the ways in which they harm the forests it is necessary to understand more about them as a class and in particular to see how they live and multiply. There are more stages in their life history than is the case with other animals, such as, for example, birds or fishes from whose eggs or spawn young birds and fishes are hatched direct. The majority of insects pass through several distinct stages of development so unlike each other as to be unrecognizable without special knowledge. The adult insect known as the *Perfect Insect* or *Imago* lays eggs from which hatch out *Larvae* (Caterpillars or grubs) which are small at first but which feed and grow. The *Larva* when fully grown becomes dormant usually after covering itself with a protective cover of some kind and it is then said to have become a *Pupa* (Chrysalis). During this resting stage the larval shape is altered, rudimentary legs, wings, heads, etc., are developed and at the end of the stage the pupa emerges as a perfect insect or imago again. This life cycle is said to be complete when all the stages are gone through in turn as in the case of the silkworm. Some insects, however, for example the grass-hoppers, miss out some of the stages and the metamorphosis is then said to be *incomplete.*

87. The details of the stages of development of any particular insect including a study of its structure, habits of feeding and resting in each of the various stages, periods of the year in which the various stages are passed through, and any other known facts about it, make up what is known as its life history. Before we can attempt to devise any method of controlling an insect pest or to encourage the development of useful insects we must make a careful study of their life history. Unfortunately for us in this country research into the habits of forest insects is rather backward and there are but few cases in which the life histories of even common pests can be said to be thoroughly understood. Steps have been taken however to remedy this defect and matters will steadily improve as time goes on and our knowledge increases. Every forest officer can help by recording and reporting any observations he is able to make, also by collection of specimens of insects and the damaged material if necessary. The post of Forest Zoologist for Burma will probably be filled sometime in 1927. In the meantime research work in this subject is conducted by the Zoologist at the Forest

Research Institute and College, Dehra Dun, to whom specimens may be sent. Full instructions as to collection, preservation, packing and despatch of Insect specimens are given in "Departmental Instructions" as well as a list of particulars of the information which is required in each case.

88. *Various Kinds of Insects.*—Insects can be divided according to differences in structure into several orders of which the following are of special interest to Foresters :—

Insecta
Coleoptera (Sheath winged insects).
Orthoptera (Insects with straight folding wings).
Neuroptera (Insects with net-veined wings),
Isoptera (Termites or white ants).
Hymenoptera (Hooked-wing insects).
Lepidoptera (Insects with scale-covered wings).
Rhyncota (Insects with wings half sheath like and half membraneous.
Diptera (Two-winged insects).

All except the Diptera possess four wings.

A short description of these orders with examples of the insects comprised in them will be given before taking up the study of individual species.

89. *Coleoptera* (Beetles).—These are minute to large insects whose forewings are modified into horny or leathery sheaths known as Elytra which meet in a straight line down the centre of the back. Their hind wings are membraneous, used in flying and fold beneath the elytra when not in use. Sometimes these wings are reduced in size or are wanting. Mouth parts are adapted for biting. The metamorphosis of these insects is complete and their larvae are called grubs. They are very numerous and different species attack every part of a tree from the roots to the flowers.

90.—*Orthoptera* Insects with biting mouth parts. Forewings elongated and narrow with some hardening and hindwings more membraneous and delicate. The hind legs may be elongated and adapted for jumping. Metamorphosis is incomplete. This order includes cockroaches, stick insects, grass hoppers, etc. The most destructive insect of this order is the Locust.

91.—*Neuroptera* Soft-bodied insects with biting mouth parts. Two pairs of very similar membraneous wings. Larvae are carnivorous. Many spend their larval stage in water. This order is important as its members live on and destroy large numbers of other harmful insects. They are not harmful to forests.

92. *Isoptera.*—Social species living in large communities made up of winged reproductive individuals and sexless or

sterile wingless workers. Biting mouth parts and metamorphosis slight or absent. "White ants" are included in this order.

93. *Hymenoptera.*—Insects with distinct constriction between thorax and abdomen, two pairs of membraneous wings, the hinder pair being smaller and interlocked with the front ones by means of hooks. Mouth parts adapted for biting but often for sucking as well. An ovipositor (egg placer) is always present and is developed or modified for sawing, stinging or piercing. Metamorphosis is complete. This order contains ants, bees, wasps, ichneumon flies, etc. Some of these do damage but the last named are useful as they all prey on harmful insects and destroy them.

94. *Lepidoptera* (Butterflies and Moths).—Insects with two pairs of membraneous wings. Clothed with broad scales all over the body and wings, and with only poorly developed sucking mouths. Metamorphosis complete. Butterflies and moths in the imago stage do no damage but in the larval stage live almost entirely on foods of vegetable origin and do an immense amount of harm all over the world.

95. *Rhyncota.*—Usually two pairs of wings. Mouth parts adapted for piercing and sucking. Metamorphosis rarely complete. Most of them have a disagreeable smell and they are generally called bugs. Included in the order are Aphids or Plant Lice, Cicadids and the "Lac" insects.

96. *Diptera.*—Insects with a single pair of wings. Mouths adapted for sucking or piercing. Metamorphosis complete. Includes flies and gnats which, although not of direct importance to forestry, nevertheless affect the life of everyone so seriously as to be worthy of mention.

97. Each of the orders mentioned above is again subdivided into numerous subdivisions. The detailed description of these is, however, outside the scope of this book and all that will be attempted is a short account of the more important insects, in each main order, which effect living trees or timber or which are of sufficient interest to warrant special mention.

CHAPTER XIII.

Coleoptera (*The Beetles*).

98. These are very common indeed and both the beetles themselves and their larvae do damage; the former by eating leaves, roots and shoots, etc., the latter more usually by boring galleries in the wood and bark or devouring seeds.

On the other hand, the so-called "lady-birds" are so useful in feeding on aphids or plant lice, etc., that in America they are bred for this very purpose.

99. A common pest of teak is called *Haplohammus cervinus* which usually attacks poles and saplings. The larva bores long galleries in the pith of epicormic branches and also of yearling shoots, following the pith down into the heartwood. Young shoots when attacked are easily broken off and if the leading shoot of a teak tree be destroyed in this way forking of the stem is caused. In any case there is an open and dirty wound liable to cause rot. Unfortunately very little of the life history of this pest is known.

100. Other larvae of common beetles have been found to cause swellings and to bore holes both large and small, the latter resembling shot holes, in dead trees of teak and other kinds. Several varieties also lay their eggs in the bark and the larvae later feed between bark and wood, of course injuring the cambium layer in so doing. This form of attack is often done in a regular pattern, for instance, some of the so-called bark beetles are polygamous and have a central chamber where the male beetle stays. From this chamber the females bore galleries in which to lay their eggs while the larvae, which hatch later, each bore their own galleries at right angles to those of the mother beetles. In this way many intricate patterns are formed and it should be noted that each beetle always adopts the same pattern so that once known the beetle can be identified from the pattern or arrangement of the galleries.

101. Bamboos when felled are extremely subject to a pest which bores tiny holes into the stems. This pest is known as the "bamboo shot-borer" from the appearance of the attacked stems which look as if they had been riddled by small shot. The damage is done by small beetles, several kinds of which are known, which lay their eggs on the bamboo. To preserve bamboos the best way is to keep them in water so as to prevent beetles from getting access to them from the time of felling till they can be treated with earth oil. The treatment with earth oil must be repeated at fairly frequent intervals.

102. The few examples mentioned in the preceding paragraphs are merely a very small fraction of the almost innumerable harmful beetles, but they will serve to indicate how best to protect the forest against this particular class of insect. Leaf and shoot-eating beetles can be shaken or picked off by hand and destroyed, in the case of individual

trees or in nurseries, though this is not practicable over large areas of forest. Since they usually pupate or at least spend a part of their existence on the ground or among dead leaves on the ground we must encourage their natural enemies, such as birds, lizards, pigs, etc., while it is probable that the annual fires destroy a good many of them. Bark and woodboring beetles usually attack dead or sickly trees and breed in the bark and stumps of fallen trees. When practicable therefore dead trees and logs should be barked and the bark burnt. In Europe, where these pests are very destructive, sometimes the dead stumps are all extracted and removed after the trees have been felled. The best protection of all is good silviculture, *i.e.*, to grow only species best suited to the circumstances and to keep the forests healthy and vigorous by careful tending. Sometimes when it is known that a pest breeds in a special place, *e.g.*, in the bark of a fallen tree, such places are deliberately prepared to induce the insects to breed in them and at a suitable moment the "trap" tree as it is called is burnt or the insects otherwise destroyed.

CHAPTER XIV.

THE ORTHOPTERA (*Insects with straight folding wings*).

103. This group of insects is not so harmful to forests as the beetles. It includes cockroaches, grass-hoppers, preying mantis, crickets and locusts, of which the latter is extremely destructive to crops, over which it swarms in huge numbers, obliterating whatever it attacks. They are not, however, very important in forestry and the cricket is perhaps the most destructive of the group owing to its habit of biting off young seedlings, particularly in nursery beds. *Payit* or green grass-hopper is a pest on rice plants in *taungyas.* Insects of this group are nearly all able to produce a chirping sound which is caused by rubbing the wings or sometimes parts of the legs together. By whatever organ the sound is produced it is caused by rubbing a surface like a file over a scraper-like surface at a high speed giving rise to the penetrating sound so commonly heard in the evenings whenever any of these insects are about.

104. Measures of protection against this class are rather difficult to make effective. In nurseries something can be done by direct destruction and by clearing undergrowth and grass for some distance around thus rendering breeding and

hiding places more scarce. Ploughing up and burning the soil also destroys a good many, while natural enemies such as birds, monkeys and squirrels catch and eat the larger varieties. On the other hand, many of this group are carnivorous and prey upon other insects so that they are actually useful to us instead of being a pest.

CHAPTER XV.

THE NEUROPTERA (*Insects with net-veined wings*).

105. This class of insect is distinctly useful as all of them are carnivorous and prey upon other insects especially soft-bodied ones. Many of them breed in or near water and some are aquatic in their habits. Ant-lions and " lace wings " are the best known members of this group.

CHAPTER XVI.

THE ISOPTERA (*Termites or " White" Ants*).

106. The name " White Ant " is unfortunate as the insect is but distantly related to the true ants but the use of the term is so common that it must be continued to avoid confusion. The destructive habits of these insects are so well known that it is unnecessary to describe them in great detail. They live in social communities or ant-hills sometimes several feet high. In such a community there are males and females which have wings ; " soldiers," with strongly developed mouth parts, who guard the nest, and " workers " who are sexless, wingless and with smaller mouth parts. The " workers " far exceed the others in numbers and do all the work for the community including building the nest and providing food for the other inmates.

107 At the beginning of the rains, usually at dusk, the winged males and females swarm out of the nests into the air and fly for a short distance during which flight those which escape their numerous enemies pair and drop their wings. The female is then imprisoned in a cell where she lays eggs *at the rate of about one per second* and grows herself to about one thousand times the size of the ordinary " workers." The eggs and larvae are kept in surrounding galleries and thus the community grows in size and destructive power. Since only the " queen," as the egg-laying female is termed, can reproduce the species the destruction

of "soldiers" and "workers" is of little use and to stop their increase it is necessary to locate the "queen" and destroy her. Even this is only a temporary check as there are other pairs of male and female ants which can by extra feeding be developed so as to take the place of the first royal pair.

108. White ants sometimes attack living plants if they are unhealthy but usually they attack only dry wood, paper, cloth, etc. They prefer sapwood to heartwood and do not attack the heartwood of teak at all owing to the oil which it contains. As they never appear in daylight they tunnel their way under the surface unseen and often the first sign of their attack is the collapse of the article which has been hollowed out to a mere shell. Timber or other materials liable to attack should not be kept in contact with the ground and the surfaces of posts, etc., which must be put into it should be charred or thickly coated with tar or other preservative before use.

CHAPTER XVII.

THE HYMENOPTERA (*Hooked-wing Insects*).

109. This group is a very large one indeed, the best known members being the bees, ants and wasps. Some of the varieties of these insects have adopted the habit of living together in large communities very much after the fashion described above in the case of "White Ants." In such species reproduction is usually performed by a "queen," the other females being "workers," but in certain cases among the wasps the females of the colony also reproduce their kind. The males exist solely to mate with the females and when mating is over they frequently die or are killed by the "workers." The females of this group all have an ovipositor (egg placer) at the hind end of the abdomen, which may be adapted as a sting or shaped like a saw to enable the insect to make a hole in which to lay eggs.

110. These insects are the cause of "galls" which may be found in roots, bark, stalks, twigs, buds, leaves, flowers and fruits according to the habits of the insect concerned. Unless fruits are all destroyed or terminal shoots deformed however the damage cannot be said to be very serious especially when compared with the good work which is performed for us by bees and other insects of this group. Some galls are even useful, *e.g.*, galls on oak trees which have been found to be rich in tannin. Honey-bees produce

honey and bees-wax and the product known in Burmese as *pwenyet* is made by another small kind of stingless bee (Melipona). Ants devour the eggs of other harmful insects and even prey upon the insects themselves.

111. The usefulness of bees in the above-mentioned ways however is small compared with their utility in spreading pollen from flower to flower and thus fertilizing them. Attracted by the colour of flowers bees fly to them in search of honey which is secreted by small glands well down inside the flower, so far out of reach in many cases that the bees have to crawl down into the flower right out of sight. Their backs or their legs are provided with stiff hairs which rub against the pollen sacs and carry away some of the pollen on them. When they enter another flower some of this pollen is rubbed off on the style or stigma and causes it to become fertilized. Without the visit of the bee then there would be no fertilization and no fruit or seed would be formed, for flowers which depend on bees for this service are so adapted for it that natural fertilization is impossible by any other means.

112. The group contains another class of insects not yet mentioned which are useful to foresters in quite a different way. These are the so-called Ichneumon Flies. They, perhaps more than any other factor, help to keep down the numbers of injurious insects such as beetles and moths by laying their eggs inside the soft bodies of the grubs and caterpillars, which are merely the larval forms of beetles and moths. After hatching the Ichneumon larvae feed on and destroy the bodies of their hosts thus killing off immense numbers of these pests. Sometimes it is the pupae of beetles or moths which are thus parasitised, but in any case the result is the same. Unfortunately some of them deposit their eggs in useful insects such as the bee and the "lac" insect, but on the whole their influence on forestry is extremely good and useful.

CHAPTER XVIII.

LEPIDOPTERA (*Moths and Butterflies*).

I.—*General.*

113. These insects are very well known from their great number and variety as well as their brilliant colouring (in the case of butterflies). All of them are covered with scales

and have a mouth either so ill-developed as to be useless, or intended merely for sucking up liquid substances such as the juice of flowers, over-ripe fruit, or honey dew. The insects themselves are therefore incapable of doing any harm, but their larvae are furnished with strong mouths for biting and do an incredible amount of harm in devouring foliage, flowers and shoots or boring into stems and roots. This is especially the case with the larvae of moths; in fact the damage by butterfly larvae is so small in comparison that in this book no further mention of it will be made. Their larvae are mostly leaf-eaters which prefer herbaceous plants and the harm done is more than set off by the usefulness of the butterfly in fertilizing flowers while in search of honey, etc.

114. *Butterflies* can be roughly distinguished from moths by the following features. They have rather long, thin antennae ending in a knob. Their fore and hind wings are never hooked together and in repose are held erect. They appear by day and are brilliantly coloured very often so as to enable them to harmonize with the colours of the flowers they visit to such an extent that if they sit still they are almost invisible to their enemies.

In *Moths*, which fly mostly by night, the antennae are rarely knobbed but are more or less broad and shaped like a comb or brush with a fringe at the edge. Their wings hook together and in repose they are kept flat.

115. *Life History of Moths.*—A lepidopterous larva consists of a more or less cylindrical worm-like body with a head and twelve segments, of which the first three behind the head have jointed hairy legs. The next two segments have no legs but the sixth, seventh, eighth and ninth segments have each a pair of sucker legs provided with small hooks for clinging to leaves, etc. The tenth and eleventh segments are legless, while the twelfth and last bears a pair of clasping legs. The larvae are usually called caterpillars.

Some of them are highly coloured, some are naked and some are very hairy. They live on or in practically every part of a plant. They may become mature in a few days or live three or four years. When mature they pupate or, as we commonly express it, they enter the "chrysalis" stage generally inside a cocoon of silk. The cocoon may be merely silky in nature with other ingredients to make it more lasting and weatherproof. Pupation takes place in the ground or in rolled up leaves or in a chamber hollowed out of a stem. When fully developed the pupa bursts its cocoon and emerges as a fully developed moth except that the wings are soft and crumpled. The moth however remains still except for expanding the wings which are spread out and dry ready for flight in something less than two hours from emergence. The sexes take flight and pair after which the female lays her eggs. Moths die after a very short life especially short in those cases in which the mouths of the insects are rudimentary and of little or no use for feeding. Eggs are laid in the ground, on stems, leaves, bark, etc., according to the kind of existence the larvae will lead later on. From this short account it will be seen that the longest stage in the life history and the most dangerous one to forest growth is that of the larva.

116. *Importance of Moths.*—Practically all moths in their larval stages are destructive to forests, but in the case of the silk-worm the damage done by the larvae feeding on leaves is paid for by the value of the silk taken from their cocoons. In fact the silk-worm is cultivated and provided with food—generally the leaves of the mulberry—for the sake of the silk produced.

Since silk-worms are so common students who wish thoroughly to understand the life history and metamorphosis of a lepidepterous insect cannot do better than keep a few through all their stages for the purposes of study. To emphasize the importance of the damage due to the devastating habits of these insects, three or four of those best known in Burma will now be described in somewhat more detail.

II.—*Bee-hole Borer of Teak.*

117. *Distribution.*—For many years past it has been known that teak trees were attacked by an insect which bores holes into the heartwood sometimes to such an extent that the timber is riddled with holes and is useless. The loss due to this damage has been variously estimated from ten to fifteen or more lakhs of rupees *annually*. The distribution of the insect is coincident with that of teak, it being especially prevalent in the better stocked teak forests, in plantations or groups of pure teak and in some types of moist forest. It is less prevalent towards the natural limits of the teak, *viz.*, in regions of higher altitude and rainfall over 150 inches per annum. Certain forests in Katha and the Shan States have a particularly bad reputation for bee-holed timber.

118. *Habits of the Insect.*—The first event in the attack is a boring made through the bark down into the sapwood where as the larva grows it excavates an irregular chamber. This is usually more or less star-shaped though there is considerable variation in it. The chamber is enlarged as time goes on and the larva feeds on the callus formed by the cambium round the edges of it until it has become fully developed. Meantime it has at intervals bored a *gallery into the heartwood towards the centre of the tree and upwards* until the hole is from 7 to 9 inches long. It is important to note that the boring is always upwards and never downwards. When mature the larva closes the hole with a coarse silky web and ascends to the uppermost portion of the gallery. Here it spins another covering and shuts itself up in a closed chamber to pupate. When ready to emerge the pupa bursts its way through the covering of the pupal cell by means of a hard process on its head and wriggles down into the sapwood chamber by the help of backwardly directed teeth or spines on its abdomen. It then pushes itself through the hole in the bark until it projects about an inch into the air. Shortly afterwards the pupal skin is burst open and the moth emerges to walk a foot or two up the tree leaving the empty pupal skin sticking out of the hole. The moth stays motionless until its wings have developed in the way already described, a process which in this case takes about an hour. It is then ready for flight, which takes place at night, and after mating the female proceeds to lay the eggs which will produce the next generation of insects.

119. *Seasonal Development.*—The emergence of the moth takes place, usually near midday, from the middle of April to the middle of May, *i.e.*, just before the break of the rains. Eggs are laid within two or three days and tiny larvae just beginning to bore into the bark are found from the end of April onwards till into July and even in August though this is probably usually late. It seems most likely that the hatching of the larvae is timed so as to bring them out after the season's growth of the tree has begun as unless the sap is active they would probably perish for want of nourishment. Normally it would appear that the larvae are fully grown by the end of the growing season of the tree and pupate then, so as to emerge at the end of the dry season. Since half-grown specimens have been taken at that time however it appears probable some larvae might take two years for their development. The study of the life history is

however far from complete and much further investigation and research is necessary.

120. *Description of Insect.—The moth* is a pale, greyish-brown insect 2 to 3 inches long with pale brown, rather indefinitely marked wings which in the female have a spread of 4 to 6 inches ; those of the male being rather smaller. The average in Burma is about 4 inches. The general appearance is very variable but it bears a great resemblance to teak bark, this of course being useful to the insect in protecting it from being easily recognised and caught by its natural enemies. Its scientific name is *Duomitus ceramicus.*

Eggs laid by moths in captivity are sulphur coloured cylinders with rounded ends each about 1/24th of an inch long and strung together in clusters of 100 or more. Where they are laid under natural conditions has not been discovered yet but it is conjectured that they are laid on the bark of teak trees or in crevices in it.

The *larva* is smooth and shining with a body marked by alternate pink and white bands and prominent brown oval spots on each segment. The head is prominent, reddish to chestnut brown in colour and with black jaws. The larva grows up to 2½ inches in length.

The *pupa* is enclosed in a horny smooth, shining case which is light brown at first but which darkens to become almost black when mature. The female pupa averages about 2¾ inches and the male about 2¼ inches long.

121. *Liability of Trees to attack.*—Bee holes are found in both vigorous and weakly teak trees from the time they begin to develop any heartwood, *i.e.*, from even the second or third year till old age. Up to about 15 years old the greater number of holes are found in the basal 6 feet of the tree but after that there is much variation and no data for further statements of this nature. Pure crops such as plantations are naturally likely to be more seriously attacked than isolated trees as the moths find host trees ready to hand and lay their eggs safely, without so much danger of falling victims to their numerous enemies while searching for a tree to attack.

122. *Damage done.*—The damage done to trees is not fully apparent till the timber is sawn up since the sapwood chamber is covered over by callus after the moth has emerged. (As many as 1,000 bee-holes have been discovered in *one log*, when it was opened up on the saw bench.) Apart from the holes due to the larvae many more are made by wood-peckers which pierce a hole through the wood into

the gallery and extract the larva or the pupa from it. These holes always open up the top end of the gallery and add to the mischief already done while they also open a wound which may lead to the entrance of a fungus disease.

123. *Protective Measures.*—From the knowledge we have at present it is somewhat difficult to devise any real protection from the bee-hole borer. Further research is needed. For instance if we knew where to look for the eggs we might be able to destroy them by some simple means. At any rate we should know if it was feasible to try to do so. The time spent by the larva just after hatching and before it begins its boring is obviously a vulnerable period as it is then crawling about on the surface of the bark. We must therefore encourage all animals which are known to eat insects or their eggs, especially insectivorous birds. It has also been proved that certain Tachinid flies and certain Hymenoptera parasitise the larvae of the bee-hole borer. Such insects should therefore be regarded as allies and not be destroyed. Further research *may* show us methods of encouraging these parasites though perhaps this is looking rather far ahead.

124. *Palliative Measures.*—Rules designed to lessen the intensity of attack are the following :—

(1) Avoid large even-aged areas of pure teak. This is fairly easy if we make plantations of it only on the very best soils—filling in the blanks on less suitable soils with other species—and encouraging the development of an undergrowth of bamboos and other trees under our teak.

(2) Thin early and often so as to get a high girth increment as compared with the increase in the numbers of bee-holes.

(3) Remove suppressed and dominated trees when thinning since these help to swell the numbers of insects bred out and thus infect more valuable ones.

(4) Fell thinnings between August and December, thus causing the death of larvae in these trees. If felled while going through the pupa stage the insects will still be able to emerge and breed more of their kind.

125. *Conclusion of Notes on Bee-hole Borer.*—In the space available here it is impossible to give a full account of the Bee-hole borer. Students should study the Records and Bulletins already published on the subject and must remember that information is still being collected. It is probable that in the course of a year or two this account will need to be completely re-written and considerably amplified.

III.—*Teak Leaf Defoliators and Skeletonisers.*

126. The larvae of a moth known as *Hybloea puera* frequently eat the leaves of teak trees over large areas of country. This insect is called the Teak Defoliator (though it is by no means the only one) and it is commonly found with another one called the Teak Skeletoniser (though this again is only one of several) of which the scientific name is *Pyrausta Machoeralis.* The two are distinguished from one another by the manner of their attack, the defoliator eating the whole leaf except for the mid-rib and main veins, whereas the skeletoniser eats only the soft tissues, leaving a fine mesh of veins and veinlets with the margin of the leaf entire.

127. The defoliator moth is small and is dusky in colour with reddish patches on the hind wings. Its larvae pupate in rolled up leaves or in dead leaves on the ground. The eggs which are laid on twigs and leaves hatch out in April and the insect passes through several generations in a year. The skeletonizer moth appears in May and passes through a generation a month up till November or December. Its larvae which pupate in cocoons in the ground are unusually lively and abrupt in movement.

128. The defoliation caused by these insects causes loss of increment to the trees and may cause the formation of a "false ring" in the timber but the damage is usually not desperately serious unless the attack is repeated and is severe. If it causes the complete loss of foliage just after the first flush, the tree puts out another crop of leaves thus seriously depleting its stock of reserve material and if further new flushes be eaten in turn, before the tree has time to build up more food material through the leaves, the effect is very serious and may even result in the death of the tree. On the other hand if the attack is not really severe till the end of the season little permanent harm is done.

A more serious result has been noted in plantations of 3—10 years old which, after attack, sent out a new flush of leaves in the cold weather but could not get enough water from the ground at that time of year to supply the top of the trees. The leading shoots died, with the result that the trees became forked.

129. Protective measures are the encouragement of those animals which feed on caterpillars and pupae in the ground and the cultivation of crops which are not pure teak. Ground fires are probably also useful in destroying the

pupae but fire, of course, must be used with caution. If it is desired to protect a few trees grease bands may be put round the stems as these prevent the caterpillars from ascending or descending them. When very numerous, the caterpillars can be shaken off or caught by hand and destroyed. Such measures are naturally only possible on a very small scale. Birds eat the caterpillars in thousands.

IV.—*Shoot-borers.*

130. So far we have studied two kinds of ways in which moths do damage, *viz.*, by boring into wood and by devouring foliage. As an example of a third kind we may take what is called the "Toon" shoot-borer which attacks the tree called *Tawtama* or *Thitkado* (*Cedrela toona*). This is a night flying moth called *Hypsipyla robusta* which lays its eggs in March. The larvae hatch and live by feeding on the flowers. A second generation appears early in April and feeds on the fruits. The third and fourth generations live in young shoots from early May to mid September and the fifth brood appears about October. This generation hibernates in the larval stage inside the shoots till about mid February, when it pupates before emergence in the second year. Damage is therefore done by reducing the chances of fertile seed since both flowers and fruits are destroyed. The borings into young shoots kill them or cause them to break off with consequent formation of swellings and forking as other shoots arise to replace the dead ones. Although the attack is usually very severe the trees seem to develop a stem eventually though it may be branched and bushy in consequence of the struggle. This insect is common in Toungoo, Katha, Myitkyina and Bhamo among other places, especially in plantations. It is somewhat unusual in that it feeds on several trees including *Yinma* (*Chickrassia Velutina*), Mahogany, and the common lime and hedge-rose as well as other species of *Cedrela*.

131. Methods of control have been proposed but they are not very practicable on a large scale. They include :—

(i) removal of all host trees in the neighbourhood before a plantation of *Tawtama* is made.

(ii) Sack-banding all flowering trees when the flowers appear. This is done by wrapping a piece of sacking about 12-inch wide round the tree, tying it round the middle and turning the top portion over after the fashion of a stocking over a garter. Cocoons and larvae collect inside the band and can be destroyed.

(iii) Pruning and destruction of attacked shoots in the cold weather. In practice the attack of the pest almost rules out any possibility of forming a successful plantation on any large scale at all though avenues (for which *Tawtama* is frequently planted) can be established by taking the precautions mentioned above.

CHAPTER XIX.

The Rhyncota (*Plant Bugs*).

132. With the exception of a very few which suck the blood of mammals and birds the members of this order live on the sap of plants. Like bugs and lice which live on animals they have mouths adapted for piercing and sucking. They commonly live on leaves in large numbers, draining away the sap and robbing the plant of its food while also opening wounds which allow fungi and bacteria to enter. They are also known to transmit diseases and " blights " from plant to plant by means of their piercing mouth parts. They multiply very rapidly and were they not the prey of other insects, such as beetles and birds, they would very soon overwhelm the plants they attack. A great many of them have the power of secreting wax with which they cover themselves either in the form of a powder or a thread-like mass. The insect which is found in white masses under the leaves of garden plants belongs to this order as does another one known as the " Lac " insect. This is most important from the forestry point of view since India and Burma are the principal " lac " producing countries of the world. Lac is in great demand for the manufacture of such things as varnish, sealing wax, gramophone records and insulating material in electrical work. Many of these plant bugs pass sweet excretions which are known as " Honeydew."

The " Lac " Insect (*Tachardia Lacca*).

133. The insect feeds on tender shoots of very many trees *e.g.*, *Pauk* (Butea frondosa), *Nyaung* (Ficus spp.) *Zibyu* (Phyllanthus emblica). *Thitnu* (Engelhardtia spicata) and many others. In India the best " lac " is produced on the " *Gyo* " tree (Schleichera trijuga) but this tree is not

usually attacked in Burma. It likes a comparatively cool climate where there is not too heavy a rainfall and thus in Burma it is found growing best in elevations of about 2,000 feet upwards as in the Shan States and Arakan Yomahs. In recent years it has been cultivated in the forest reserve around Maymyo both on jungle trees and on "*Pe-sin-gon*" (The Dhall Plant) planted for the purpose. The "lac" grown on trees is however superior. "Lac" has been found on no less than 37 species in the Maymyo Reserve including trees, shrubs and woody climbers.

134. *Life History.*—The larvæ of the insect swarm twice a year, the dates of the swarming varying from place to place. Once however the dates are known for each locality it is practically certain that swarming will take place on or within a few days of these dates in future years. In Burma at Maymyo it begins from the middle of April to the beginning of May and again in October-November. It is important to observe and fix the exact dates for reasons which will appear later. The swarming goes on for approximately three weeks during which time the twigs with tender bark become pink or red in colour from the masses of the tiny red larvæ which cover them. Heavy rain at such times is dangerous to the insects which may be washed away by it.

The maximum distance the young larvæ can travel is about 9 feet and they must find a place in which to settle and pierce the bark to obtain sap within this distance. They must do this within 24 hours of swarming otherwise they die. When settled, and only tender bark can be utilized by them, they suck the plant juices and cover themselves with a resinous incrustation. Males and females swarm together and become mature in about two months. The females in covering themselves with the incrustation leave three filaments sticking out through it to preserve apertures one of which is for breathing, one for the anus and another for access to the sexual organs which are reached by the mature males crawling over the mass of insects. The males then die. This period is again a dangerous one as if the males are killed or washed away by rain the next brood will not be so numerous as it should be. After impregnation the females secrete the "lac" at a greatly increased rate and they deteriorate into mere sacs unable to move and full of eggs. Four months after impregnation the females hatch out the young larvæ and die, the larvæ living on their bodies for ten days before swarming out for the second or winter brood. This brood follows the same course save that it becomes mature more quickly and the larvæ hatch again after four months from the swarming. For this reason, and because during these four months there is less sap available for food than during the rains, the amount of so-called winter "lac" is less than the summer "lac". The females are wingless and so are the males of the first generation but in the second generation they have a pair of transparent wings. Exceptions to this rule have been reported and it is possible that there is more than one species.

135. *Enemies of "lac" insect.*—Ants eat the sweet excretions and bite off the anal filaments for this purpose. Birds and monkeys destroy them, caterpillars eat them and they are parasitised by other carnivorous insects. Exceptional drought, fire and heavy rain also destroy large numbers.

136. *Propagation and Cultivation.*—Since the product is so valuable steps are taken to cultivate the "lac" insect and for this purpose an accurate knowledge of the swarming dates is necessary. Propagation is done by tying twigs containing young larvæ in the forks of other "lac" free branches of suitable species just before they swarm. The larvæ then crawl up to the tender barked shoots and infect them. If the "lac" encrusted branches be cut before the females have hatched the larvæ they may die from starvation and no swarm will take place. On the other hand if delayed too long, the larvæ will all have left before the twigs are used for infection. If only adjoining trees are to be infected it is advisable to wait till the first larvæ begin to emerge and then to cut the twigs but if it is desired to remove the "Brood lac" or "Seed lac" to a distance an attempt must be made cut to the twigs just at the time the females die. The twigs can then be transported anywhere within a ten day's journey and used for infection purposes. Once established on a tree all that is necessary is to leave a few branches uncut at the time of collecting the "lac". "Seed lac" should be placed on the same kind of host tree or at any rate on one with a bark not harder than the original host otherwise the larvæ may not be able to penetrate it. Under cultivation it is usual to pollard the host trees systematically so as to produce as many tender juicy twigs as possible.

137. The collection and propagation, etc., of "lac" and "lac" dye from the bodies of the insects, for the market is dealt with fully under the subject of Utilization. Although Burma is well suited for the cultivation of "lac" not very much has been done, partly because of the difficulty of protecting the product (which grows over wide areas of the

jungles) from theft just before it is ready for collection, and partly owing to rather violent fluctuations in the market price.

CHAPTER XX.

THE DIPTERA.

Two Winged Insects: Flies, etc.

138. This class of insect has no direct influence on plant growth but is important from the point of view of hygiene. The common flies have sucking mouths and live on carrion and all kinds of filth. Having been contaminated by walking and feeding on such material they alight on our food and are thus the direct cause of diarrhœa, dysentery, cholera and other bowel complaints. These kinds of flies breed in excrement and filth, particularly in cattle manure, so no accumulation of such dirt or rubbish should be permitted near houses or camps. Open latrines should be at a distance and be regularly disinfected or covered over with a thick layer of earth. Flesh flies lay their eggs in sores and wounds or under the skin of cattle there producing maggots or grubs. Open wounds on elephants and other animals must therefore be disinfected and kept free from flies as far as possible. Smoke helps to keep flies away from animals.

139. Mosquitoes are insects which breed in stagnant water. When sucking blood they transfer to the body germs which cause various diseases. For instance, the Anopheles mosquito carries the germ of malaria, part of the life cycle of which is passed in man and part in the mosquito. The large striped mosquito common in Rangoon has been found to transmit the germs of Dengue fever. The Anopheles mosquito may be recognised from its habit of resting on its two front pairs of legs with its body and hind pair of legs held at an angle with the surface to which it is attached. They fly only from evening till early morning so that protection from malaria can be effected by protecting the body from bites after sunset and sleeping beneath a mosquito proof curtain.

Mosquitoes lay their eggs in water. Their larvæ hatch and live as tiny wriggling creatures with their heads just at the surface of the water. They can be killed at this stage by pouring a few drops of Kerosene oil on the water. This spreads over the water like a film and suffocates them. Since prevention is always better than cure it is preferable however to prevent the breeding of mosquitoes by draining all hollows or filling them up ; also all old wells, etc., and by taking particular care to leave lying about no empty tins or old bottles, etc. Since a very small quantity of water is sufficient, even two or three drops of water on a big leaf may form a breeding place. Houses should be built on well-drained sites at a distance from tanks or open wells, dense jungle, etc., since mosquitoes cannot fly very far and are not strong enough on the wing to fly against a moderate breeze. Considerations of this kind are important when selecting sites for Rest-houses, etc. Since fish eat the larvæ tanks and canals should be stocked with them as a palliative measure.

140. *Parasitic Flies.*—These are a carnivorous family and breed mainly in the bodies of lepidopterous larvæ through they also select as hosts larvæ of Orthoptera, Rhyncota and Hymenoptera as well as both adults and larvæ of Coleoptera. They live in the neighbourhood of vegetation, *i.e.*, where insect pests abound and are therefore extremely useful in keeping their numbers down. They are thick-set bristly flies, some having long slender legs. We have proof that among their many and various victims the larvæ of the bee, hole borer are included so that for this one reason alone these flies must be classed as of great importance in Burma teak forests. Unfortunately not very much is known about the Burma varieties save that their larvæ feed on other insect larvæ and that their pupation generally takes place in the soil.

CHAPTER XXI.

THE MOLLUSCA.

141. One other phylum of the *Invertebrata* beside the one of main interest in forestry (the *Arthropoda*), to which a short reference must be made contains a very well known and destructive pest known as the Teredo. This phylum is called the *Mollusca* and it includes oysters, snails, slugs, cuttle fish, etc. These animals secrete a calcareous shell which may be either internal or external, for example in snails and oysters it is external, and in the cuttle fish, teredo and slug it is internal. As is well known slugs and snails eat leaves among other things and thus are harmful but unless they are very numerous, as happens sometimes in nurseries, the damage is comparatively small and is kept in check by natural enemies such as birds which devour the pests.

142. The Teredo (*Teredo navalis*) is however an important pest which lives in salt water and attacks all kinds of timbers in harbour works, jetties, etc., between low and high tide levels. Ships and launches made of wood have to be protected by copper sheathing and this is the only certain preventitive. The animals attack timber in large numbers, boring into the wood leaving only a tiny hole but once inside they grow and enlarge the holes so as to destroy the timber almost entirely. One or two timbers, *Myauklok* (Artocarpus Lakoocha), *Cutch* (Acacia catechu) and *Anan* (Fragœa fragrans) are said to be proof against attack by teredo. Teak is attacked but much less than other woods of which even those resistant to white ants are badly eaten. Since the teredo lives only in salt water timber should not be stored in tidal limits at sea ports, etc. It is partly for this reason that the large teak saw milling companies at Rangoon store their logs some distance up the Hlaing River and bring down daily only their bare requirements, *i.e.*, unless they can arrange to remove the logs from the water and store them on the banks till wanted.

143. In brackish water in Burma there is another Mollusc called *Martesia fluminalis* which however only bores to about one inch deep and is therefore not so serious a pest. As stated above sheathing with copper is the only certain preventitive (iron is useless owing to corrosion by sea water) but fairly good protection can be given by injecting the timber artificially with antiseptic and poisonous preservatives.

PART III.

Protection against Plants.

CHAPTER XXII.

WEEDINGS, CLEANINGS, ETC.

144. *Weeding.*—In a forest, and particularly in young evenaged woods such as plantations or groups of naturally grown seedlings, it frequently happens that the ground is not completely covered with the crop which it is desired to grow. Wherever this is the case weeds appear ; whereas if the forest seedlings or young trees are numerous enough to close the canopy so that no light falls directly on the ground very little else is able to survive. It is the aim of good forestry always to have the soil covered so as to prevent erosion and to maintain the humus as far as possible, thus preventing loss of moisture and fertility So long therefore as the weeds are either so few or so small as not to interfere with the main crop they are actually useful and should be left. Noxious weeds such as small creepers which hang on the young trees, constrict them and pull down their crowns must of course be removed at once but so long as the others do not compete they may be left, or at most have their tops slashed off, so as to leave them alive but well below the level of the crop. They not only protect the soil but in many cases help to shade and protect tender young shade-bearing species from damage by heat and drought during the hot weather. Money spent on unnecessarily thorough weeding *between the lines* is not only wasted but direct harm is done. When the plants are small and young their roots feed near the surface and therefore shallow-rooted grasses and weeds which rob them of part of the available plant foods should be cleared all round the seedlings. As they grow older their roots strike deeper and the danger from weeds comes more from the struggle for light and air than from root-competition. Few tree seedlings can stand drip from other plants hence the main crop must always have its crowns free from danger of this kind.

Weeding should be thoroughly carried out especially in the youngest crops. Thus it is usual to weed once a month in the first growing season ; twice in the second year's life of a "taungya" plantation, at beginning and end of the rains, while one or two are done in subsequent years as may be found necessary. If only one weeding is given it should be just before or very early in the rains so as to enable the crop to profit as fully as possible from the period of the greatest growth activity, say from early June to October. The best protection from weeds is to select only the best silviculturally suited species for each locality. Such species will grow fast and soon close the canopy thus killing the weeds.

145. Of the most noxious and widely spread weeds which give the most trouble *Kaing* and *Thetke* are perhaps the most important grasses. The former is met with in low-lying alluvial soils which are often inundated and are really unsuited for teak or any of the other valuable kinds. The best way to deal with such areas is to leave them to nature and not to attempt plantations. *Thetke* is also a terrible enemy of regeneration and once it establishes itself can only be killed off by very expensive and drastic measures. It is also very injurious owing to the way it dries in the hot weather and causes a very hot fire if it gets alight. Bamboos are troublesome especially in plantations unless the stumps are properly killed when firing a *taungya*. They are only dangerous so long as the trees among which they stand are young. The roots are not killed by merely cutting the culms down but they can be killed by heaping branches, etc., on the stumps and causing a very hot fire thereby. Even if they survive this treatment for several years all they can do is to send up short, whip-like stems which can easily be cut back when weeding. In after life when the trees are big enough to stand over the top of the bamboos the presence of the latter as an understorey is very desirable indeed. They help to improve the soil conditions and keep the lower parts of the trees free from undesirable branches.

146. Probably the most important weed of the other kinds is *Bizat* (Eupatorium odoratum) which has in the last few years spread from the south over the whole of Burma. Whereas it used to be mainly a pest of Lower Burma it has appeared now in the North. [A recent Forest Administration Report noted that it appeared in Mansi Division during the war and is now known there as "*Germin Poung*" (German weed).] *Bizat* grows into an impenetrable mass if it once

gets a hold, fire has no effect in weakening it and it kills out anything except the most hardly species below it. It cannot however stand shade and if care be taken to get a full stocking in a plantation in the first year, and an early closure of canopy, *Bizat* need not be feared. On the other hand if allowed to get a start by bad stocking and careless weeding in the first season it may make it impossible to establish the crop except at such cost as to make the work financially a failure.

147. *Cleanings, Improvement Fellings, etc.*—These operations are really a continuation of weeding. The object of the maker of plantations is to close the canopy as soon as possible in early youth and he therefore leaves in the crop *any* woody species which help to do this (provided of course they do not retard the development of the main crop). Similarly in tending natural regeneration, woody species are left, even if of inferior kinds, until such time as they become a danger to the real crop. Although our valuable species grow to large size eventually and may overtop all others they are frequently outgrown in youth by smaller soft wooded species such as *Mau*, *Yemane*, *Myaukngo*, *Didu*, *Letpan* and various bamboos. Owing to their faster growth at first these species compete with the better kinds both in the soil for water and plant food and in the air for sunlight and room to develop their crowns. For instance if teak and *Yemane* are grown together the *Yemane* will suppress the teak entirely in a very few years by spreading its crowns over the teak, shading it and letting water drip on to it until the teak dies. As soon as a young crop closes its canopy therefore and is in no further danger from weeds it needs to be watched and tended by *cleanings* during which undesired species are cut out or cut back below the crowns of the favoured species. The operations described as *cleanings* then gradually rid the crop of undesired kinds of trees as soon as they interfere with others or are no longer necessary as soil protectors. Defective stems such as have suffered damage, forked trees, etc., are also coppiced back during cleanings and the object is to provide for the principal species full room for development and protection from faster growing ones. A time comes when some of the principal species must be cut out in favour of the remainder and this operation in a pure crop would be called a *Thinning*. If on the other hand the crop is a natural one consisting of many varieties the operation will be more in the nature of an *Improvement Felling* since the necessary gaps will be made

by sacrificing first all stems of less valuable species. By whatever name the operations are called they all have the same object, *viz.*, the production of the maximum amount of clean, healthy, well-grown timber of the most valuable kind or kinds in the shortest time and to do this involves the removal of anything which interferes with that object.

CHAPTER XXIII.

PROTECTION AGAINST CLIMBERS.

148. *Climbers* have a very long stem, and a large crown in proportion to their girth. For example a climber may have a crown which almost covers a teak tree at 100 feet above the ground while its diameter may be only about a foot. They also have but few woody fibres in them and therefore cannot grow upright without support. They obtain this support by clinging to trees up which they mount either by thorny hooks or by growing round the stem of the tree in a spiral manner till they reach the top where their crowns develop and spread over the crown of the supporting tree. They thus deprive the tree of its full requirements of light and air, constrict and may even girdle it while the weight of the climber may cause branches to break off. If this happens of course an opportunity is afforded for decay to begin ; fungi entering through the wound. As the climber grows it naturally thickens ; so also does the stem of the tree, the result being that the bark is tightly constricted under the climber. As this strangling action increases the downward flow of sap is restricted with the result that just above the fold of the climber abnormal growth takes place causing a screw-shaped or spiral formation of wood. The value of the tree as timber is thus reduced even if the stem is not rendered entirely useless. The roots of the tree suffer from lack of the full amount of sap some of which does not reach them owing to the constriction of the creeper above. Indirectly climbers are the cause of damage by spreading from one tree to another, binding two or three together, so that if one is blown down, or felled, branches are broken off from its neighbours. The climber may have such a strong hold on other trees as to prevent a felled tree from coming down to the ground. For this reason girdling and marking officers are always enjoined to cut all climbers on the trees they girdle or mark. The dead climbers rapidly

decay and give no trouble when the felling parties come long a year or two later.

149. To keep down climbers the only way is to cut them systematically and regularly. The operation is best done towards the end of the rains, *i.e.*, too late for them to grow up again immediately from the cut stump and before their crop of seeds has ripened. The stems should be cut in two places, one close to the ground and the other as high as the cutter can reach. The first is to kill the stump if possible and the second to prevent the possiblity of adventitious roots developing and reaching the ground. Many climbers do this if cut too near the ground while a stump two or three feet high frequently sends out shoots which encircle the tree again. Because climbers are so difficult to kill experiments have been made by brushing poisonous liquids on the ends of the cut stumps in order to kill them. Among others a proprietary article known as "Atlas preservative" has been used with varying results ; at any rate the cost is usually prohibitive. In forests when only one or two species are marketable and when we desire to increase the proportion of those species, *e.g.*, in a remote teak forest from which only floatable timber can come out, it is not worth while to cut creepers on the less valuable species but they can be left as a handicap to them while the valuable trees are freed at regular intervals. In this way costs are kept down without disadvantage to the valuable part of the crop.

The number of climbers is very large and it would be impossible to give a complete list of them here but a few of the more common ones may be mentioned. Of the large ones the following are widely distributed :—

Pauknwe (Spatholobus Roxburghii—Butea superba).
Nwesat (Symphorema involucratum).
Suyit (Acacia pennata).
Migyaungnwe (Derris scandens). (In evergreen and Delta forests.)

Others are :—

Dauktalaung or *Daungthalaung* (Dalbergia stipulata).
Donwe or *Gonnyin* (Entada scandens).
Nwengan (Salacia Smaliana).
Sindonmanwe (Tinospora nudiflora). (This is a favourite dainty for elephants.)
Subok (Acacia concinna).
Taukteletwa (Heptapleurum venulosum).
Wunu (Milletia auriculata).
Yinhnaungnwe (Vitis Linnaei).

The creeper *Taungkazun* (Argyreia spp.) is a great pest in many young "taungya" plantations and is difficult to deal with.

CHAPTER XXIV.

PROTECTION AGAINST EPIPHYTES, PARASITES AND FUNGI.

150. *Epiphytes* are defined as plants attached to, but not nourished by other plants and they vary in size from tiny things like the smaller orchids to the enormous figs, encircling large trees, which in Burma are called "*Nyaungbats*". Only these latter are important since orchids and plants of similar nature do no harm to the individual which supports them. Orchids absorb most of their food from the air and supplement it by feeding on vegetable mould, decaying matter, etc., which their roots find in the crevices of the bark of its host. They can do with very little water and can get enough moisture from the air and from the bark, etc., on which they live. No harm whatever results from their presence therefore.

151. The *Epiphytic figs* begin in a similar way but soon develop roots which run down the bark of their host into the ground. In some cases they let down thin aerial roots, like cords, which find their way into the soil below. Germination takes place on a branch or in the fork of a tree, from a fig or a fig seed left there by a bird or other animal and since birds are so fond of figs they spread the seeds over a wide area. Ficus plants may often be seen growing on the side of a brick pagoda proving that at first the plant needs little or no soil to support its growth. Nevertheless as soon as possible the roots strike into soil and the plant becomes a tree. In cases in which *ficus* seeds germinate on broken or rotten branches the roots frequently strike down the centre of the tree, down a hollow or through rotten wood to the ground. Some varieties have very heavy, wide spreading branches. To support these they let down aerial roots which develop into thick stilt-like roots. There may be 100 or more of these and the tree may cover an area of 200 feet in diameter as for example in the case of *Ficus bengalensis*, the "Banyan" tree. The commoner ones in Burmese forests entwine their roots round the stem of their host, at first like a trellis, but as thickening goes on the intervals are overgrown and the stem of the tree is entirely enveloped in a mass of the *ficus* which is very fast growing. The tree which is thus attacked is gradually strangled to death and often rots away leaving a more or less hollow stem of ficus supporting a large crown. The thick and large crowns shade other trees and prevent regeneration of more useful

species. They produce large quantities of fruits which are much appreciated by birds and other fruit eaters so that infection is rapid and widely spread.

152. The only measure of protection against "*Nyaungbats*" is to fell them. Since they will grow from cuttings they ought also to be burnt ; though in Burma we usually leave the burning to a jungle fire as it would not be practicable to hunt over hundreds of square miles to find the felled trees and to burn them, after an interval long enough to allow them to dry. *Nyaungbat* felling is an important feature of Improvement Fellings and in girdling all attacked trees (if teak and marketable) have to be felled on the spot or marked for felling green, that is to say in cases in which the envelopment has gone so far as to make it impossible to kill the teak tree by girdling it with the *Nyaung* on it. Unmarketable trees attacked by ficus are left to the subsequent Improvement Felling.

It is impossible to eradicate these pests completely as small young ones are always left owing to their being invisible from below, so the operations have to be repeated from time to time if any real good is to result.

Parasites.

153. A parasitic plant is one which grows on or in another living plant and draws nourishment from the sap of its host. It is thus distinguished from an epiphyte or a saprophyte which lives on or is nourished by dead organic matter.

154. The most important of the true parasites are the fungi. There is however another class, which are only partly parasitic, of which the commonest and most widely spread is the Loranthus family ("*Kyibaung*"). These latter germinate on the branch of a tree, having been deposited there usually by a bird after it has made a meal off the sticky fruits of the parasite on another tree or branch. The plant penetrates the bark of the branch and develops root-like organs known as *haustoria* which penetrate the cambium and draw water and nourishment from it for the parasite. The latter however develops a cambium and green leaves of its own which probably pass on some of their elaborated sap to the host, hence it is not entirely parasitic. To defend itself the attacked branch develops extra layers of bark, trying in this way to throw off the attacker ; but even if successful in this the haustoria remain and send out fresh

shoots. As a result the branch is much thickened at the point of attack and, as more and more water is robbed from it, the end of the branch withers and dies. The only cure is to cut off the affected branches and to destroy them.

155. The Dodder (*Shwenwe*) is a leafless plant which develops masses of yellow or yellowish green wiry stems on a tree or shrub sometimes quite enveloping it. It has some chlorophyll but not nearly enough to support its growth, for material for which it depends on its host. The seed germinates in the ground developing into a climber which mounts a tree or shrub and attaches itself by means of haustoria after which the roots in the ground die. If the seedling climber fails to find a host it dies. As with the Loranthus the only cure is to cut down and destroy the branches or stems attacked.

Fungi.

156. The fungi contain no chlorophyll (green colouring matter) and therefore depend entirely on their hosts for nourishment. The growing portion of fungus is called the *mycelium.* It consists of a mass of slender thin walled tubular bodies, known as *hyphae.* The thread-like mycelium spreads through the cells of its host and abstracts therefrom its nourishment. Like a root, it usually burrows out of sight and only the fructification or spore-bearing organ appears on the outside. Spores are minute bodies borne in capsules on the fructification. They serve the same purpose as seeds and are commonly produced on mushroom-like growths, which frequently give the first visible indication of attack. Sometimes the fungus lives on the outside of a leaf, or fruit, sending short haustoria into the cells for food. The so-called "Rusts" or "Moulds" are of this nature and can be seen on the surface. The spores are spread by wind or by animals and men whose feet, skin, hands or clothes have been in contact with infected material. For this reason care should be taken by those who have become possible sources of infection by handling or carrying material which has been attacked by a fungus. Fungi also spread by means of the mycelium which branches off underground and enters other roots with which it comes into contact. This method of spreading often explains the otherwise somewhat mysterious death of trees, outwards in an ever widening circle, which is sometimes found in plantations. The effect of a fungus is to cause swellings, dry or wet rot, etc., according

to the species of fungus concerned. When it is severe the attack frequently causes the death of the tree.

157. Fungi develop best in a moist atmosphere but are hindered in growth in proportion to the activity of the cells from which they get their food. For this reason sickly trees are favourable hosts while the development of the spores is favoured by wounds or diseases which offer easy entrance into the tree. Obviously then the least favourable conditions for fungi occur with good healthy trees, mixed crops and protection of the trees from injury of all kinds as far as possible. In other words, as with insect pests, *the best possible protection against Fungi is good silviculture.*

Should trees become infected they should be dug out and burnt on the spot with all the infected wood and leaves from them. If the fungus is spreading under ground a trench should be dug round the affected area, deep enough to stop the mycelium crossing it and the diseased trees and stumps should be dug out and burnt. The fungus in the ground must be killed by digging up the soil and burning it all in heaps mixed with litter and small fuel so as to bake and sterilise it thoroughly. In making plantations care must be taken to use only healthy, strong seedlings and good seed. A seedling has a better chance of resistance than a transplant as the roots of the latter are frequently broken and sometimes cut.

PART IV.

Protection against Natural Phenomena.

CHAPTER XXV.

I.

158. *Drought and Heat.*—Trees which normally grow in dry places are specially adapted by nature to meet their usual conditions of growth. Hence we need consider here only *abnormal* drought to which the trees cannot adapt themselves. The most important effect of course is failure of sufficient moisture to supply the roots which consequently cannot supply the leaves with the water they require. Since transpiration is if anything more active the tree dries up, its leaves withering and falling off. If severe the tree may die and this is especially the case with seedlings and young stock generally. The effect is intensified on shallow, stony soils with steep aspects exposing the crop to hot dry winds. Trees with long tap-roots suffer less than shallow-rooted ones. In this country drought is usually associated with heat which of course increases the transpiration and withers the leaves more rapidly than ever. The direct heat of the sun is also capable of scorching and cracking up the bark of trees. This sun-burn is naturally more prevalent on the south-west sides of the trees which are exposed to the rays of the sun at the hottest part of the day. It is more common on thin barked trees especially if these, after growing in a crowded forest, are isolated by felling their neighbours thus suddenly exposing them to influences which they have previously not experienced. The best means of protection against drought and heat are therefore good silviculture in the first place, *i.e.*, cultivation of trees such as are silviculturally suited to hot and dry situations, and secondly careful fellings arranged so as not suddenly to expose the surviving trees, causing them to be withered or their bark to become cracked. If this happens fungi enter and decay may be started. In exposed places and along the margins of the forest thick belts of trees may be left as

shelter belts from hot winds. Protection from fire and preservation of humus as far as possible so as to protect the soil from too rapid evaporation of moisture are also indicated.

II.

159. *Winds and Storms.*—Winds cause trees to be uprooted or their branches to be snapped off, opening the way for decay and disease. The gaps caused may in some cases be large enough to expose survivors to sun-scorch and bark-cracking. Since wind cannot be prevented all we can do is to minimise the damage by growing strong, healthy trees which are more wind proof than sickly ones. Thinnings and fellings must be carefully done so as not to leave isolated trees which after being in a dense crop cannot withstand the shock of wind storms until they have developed a larger, stronger root system than they previously possessed. Standards left in a Coppice with Standard forest are particularly liable to damage both from winds and from sun-scorch. They need therefore to be selected with special care. When gaps are made, as is the case along the path of a cyclone for example, the injured trees should be felled, broken poles and saplings coppiced back and if necessary and practicable, the area may be sown or planted so as to cover the soil again as soon as possible to protect it from deterioration. Plantations on areas exposed to much wind may be protected by leaving a belt of old trees to break the force of the prevailing winds which in Burma usually come from the south-west. Cyclones on the other hand more often come from the south-east.

III.

160. *Hailstorms.*—Hail occasionally occurs even in the the plains and if the stones are large enough they may do damage by stripping leaves, flowers, fruits or even the smaller branches. Owing to their rarity and local nature the damage on the whole is not very serious. In any case there is no remedy ; all that can be done is to cultivate healthy, strong crops which are less damaged than weak sickly ones.

IV.

161. *Soil Erosion.*—Violent rain does damage by washing away the soil, exposing roots, etc., and leaving the unfertile mineral soil. Crops good from the silvicultural point

of view give the best soil protection and as usual are the best means of minimising damage. When the canopy is closed, and as frequently happens there is an undergrowth of bamboos and shrubs as well, rain falls gently to the ground, its force being broken by the leaves, etc. It does not all reach the ground at once but continues to drip from the leaves and run down the trunks long after the rain ceases. It therefore has time to soak away into the ground and only a part of it finds its way into the streams immediately. Further a good deal of rain is held up by the leaves and evaporates without ever reaching the ground. For these reasons forests lessen both the quantity and impact of rain on the soil. If the cover be removed the rain breaks up the particles of soil and carries them away in the form of silt. At first the loose surface soil covered with humus absorbs a lot of water and the amount which flows away by the various drainage channels is only normal ; but as erosion takes place hard mineral soil or even rock is left on the surface. This cannot absorb water at all and the consequence is that the water running on the surface increases greatly in volume and force thus increasing its power of erosion. A vicious cycle is thus set up. Lack of cover for the soil increases the erosion and increasing erosion lessens the fertility also therefore the covering canopy. The lessened canopy increases erosion and so on, till frequently no growth is left and the surface of the ground is eroded away down to the bare rock below. This denudation of course is worse on steep slopes where the water runs with higher velocity. In such cases it is common to see large areas slide bodily down to the valleys below.

162. These so-called land-slips are usually caused by removal of the forest growth which by reason of breaking the force of the rain, maintaining the covering layer of litter and humusand the mechanical binding effect of its numerous roots anchors the surface soil in its position even on steep slopes. The only permanent prevention of erosion and landslips on hillsides is therefore maintenance of forest growth. It is for this reason that reserves, in which *taungyas* are forbidden, are sometimes taken up at the headwaters of streams used for irrigation lower down. To cure violent erosion and landslips afforestation is necessary and this is not infrequently undertaken. Since however eroded soils are not good for quick, easy or cheap plantation it is often a very expensive matter and the old maxim " prevention is better than cure " applies with more than usual force.

163. Lastly it must be remembered that streams carrying an excess of silt finally reach a spot where owing to slower rate of flow they can no longer carry the silt which is therefore dropped causing sandbanks, floods, etc. The unstable nature of the hill streams running into the Myitmaka valley and across the plains about Pegu, into the Sittang River is due to this phenomenon. Silt is however dropped in these cases not so much because it is excessive in quantity, as compared with other less troublesome streams, but because the streams are held up by running into a large mass of almost motionless water which has overflowed from the Irrawaddy and Sittang in flood.

V.

164. *Floods and Swamps.*—Floods are due primarily of course to heavy rainfall which causes rivers and streams to overflow their banks. The subject is however closely connected with the nature of the catchment areas of the streams and the amount of forest standing in them. The beds of streams are usually large enough to accommodate all the water likely to drain into them and only abnormally heavy rain will flood them. Such floods are more likely to follow extra heavy rain in hilly country where the surface water runs more rapidly into the the drainage channels and where less is soaked up by the soil. With normal rainfall a part of the water goes down into the ground to join underground supplies which feed our wells and springs, etc., while only a part of it runs off the surface into the streams. As stated in the preceding paragraphs forests reduce the amount of surface water, which alone causes floods, and therefore floods are more likely to occur when the streams giving rise to them have their source in hilly, disforested country. Anything which causes a block in the bed of a stream will naturally hold up the water in it until the water overflows the banks. This is frequently caused by " silting," a process which can be illustrated by the following simple experiment. If a few handfuls of earth be stirred up in a bucket of water it mixes with the water and is carried round by it, but if the water be allowed to come to rest it can no longer carry the earth. First of all the larger particles, small stones, etc., settle to the bottom, then the sand and finally a film of finely divided clay will be dropped. Thus when a rapidly flowing stream with silt in it loses velocity silt is dropped and it may block the channel

entirely ; the water then of necessity forces its way into a new channel. The velocity of the stream may be lessened by flowing through much flatter country in its lower reaches with much less fall for the water ; or it may be held by too narrow bridges, obstructions such as " *Taiks* " of logs and even fishery weirs. As stated above this phenomenon is common in Lower Burma (indeed in Deltas generally) where the tides holding up high water in the Irrawaddy and Sittang rivers always cause some amount of flooding annually. These large floods bank up the streams flowing towards the big rivers and form a motionless cushion which brings the silt-bearing water to rest. The subject of river training is too big for detailed discussion here but it may be defined as the art of causing rivers to deposit their silt *where it is wanted*, thus filling up low ground, and finally building up for itself banks *from its own silt* big enough to contain its own water even at high levels (See " Regulation of Rivers without Embankments."—F. A. LEETE).

165. The damage done by floods is mostly erosion and consequent exposure of unfertile soil, though of course if the flooding be sustained and the vegetation covered for long periods the trees and shrubs may be killed for want of aeration at their roots. Some few kinds of trees, *e.g.*, *Kyi* (Barringtonia acutangula) and *Pauk* (Butea frondosa), which grow in lands subject to inundation, are able to survive but most trees cannot do so. It is possible for instance to kill a teak tree by keeping its roots under water by making an artificial tank around it.

166. Floods can be prevented to some extent by maintaining forests over the catchment areas of streams and by keeping river and stream beds clear of all obstructions. Jams of logs must be promptly broken up and bridges must be designed so as not to interrupt the flow. Where there is danger of silting, obstructions such as fishing weirs should not be permitted. Streams used for floating in particular need to be cleared from time to time ; all old stumps, bamboos, fallen trees and debris brought down in the rains being hauled out on to the banks or burnt during the dry season.

167. Swamps are due to the accumulation of water in low lying places without any drainage outlet. They may be due to collection of rain water *plus* a little surface drainage or to the overflow of rivers. Owing to the deposit of silt whenever a river overflows its banks a river flowing in flat country very frequently runs along a kind of low

ridge with its bed higher than the land at a little distance on either side. Under such conditions swamps are easily formed whenever there is an overflow. The best treatment is to lead the river, or part of its flow, into the swamp when it will gradually fill it up with silt and eliminate it. Small ones may be drained though this is usually expensive and not always practicable. Swamps may be caused also by water collecting in places with an impermeable layer (Pan) under the soil which prevents the water soaking away into the ground. The water and soil in a swamp both become sour owing to the accumulation of decaying vegetable matter year by year. This is always being added to and retained so that a time comes when the acidity is so high that the water can no longer be absorbed by trees and the latter die ; really from lack of moisture although their roots are under water. If the swamp persists, in due course it develops a new vegetation of its own, all the species being adapted to the conditions, but as forest it is useless unless it can be drained. The little grassy "*kwins*," sometimes with a pool of water in the centre, so often seen in "Indaing" forest are believed to be due to a "pan" under the ground holding up the water, with the result that the soil is soured and tree growth becomes impossible. In such case breaking through the "pan" would let the water through but it is usually not worth the expense.

168. The remedy of drainage can seldom be employed in practice as the areas are not usually large enough to make it worth while. In any case the grassy swamp vegetation is useful for grazing purposes and probably the land is more valuable for grazing than under such forest as would grow on it. On the other hand a sharp eye must be kept on cultivators in the neighbourhood of reserves on flat low-lying ground or they may build bunds, etc., blocking the water channels and converting dry land into swamp. This has actually happened in recent years in Tharrawaddy Division.

CHAPTER XXVI.

CONCLUSION.

169. Throughout Parts II, III, and IV of this book the statement has constantly been made that good silviculture is the best cure, or prevention, of damage by the various causes

discussed. This fact is so important that it is well worth while emphasizing it here again. Left to herself Nature arranges to stock the ground with species suitable to each locality and adapted to the special difficulties and dangers in various places. She also usually gives us a mixed crop *but there is no tending or thinning.* There is always a struggle for existence and the weakest goes to the wall, so that in a virgin forest there are dead, dying and sickly trees while the survivors have not always their full requirements of light, air and water. Good silviculture then *follows* Nature but improves on her methods to some extent. Bad silviculture which ignores the example of Nature and plants large areas of pure crops sometimes on unsuitable soils, in unsuitable climates, is bound sooner or later to cause disaster from natural enemies.

GLOSSARY OF VERNACULAR TERMS.

Bizat	Eupatorium Odoratum.
Didu	Bombax insigne.
Gyo	Schleichera trijuga.
In	Dipterocarpus tuberculatus.
Indaing	A dry type of forest characterised by "In."
Kaing	A tall grass, Saccharum spp.
Kanyin	Dipterocarpus alatus.
Kheddah	A stockade for catching elephants.
Kyibaung	Loranthus spp.
Machan	An elevated platform used for shooting.
Mau	Anthocephalus Cadamba.
Myauklok	Artocarpus Lakoocha.
Myaukngo	Duabanga sonneratoides.
Nyaung	Ficus spp.
Nyaungbat	A tree encircled by Ficus.
Pauk	Butea frondosa.
Pe-sin-gon	The "Dhall" plant.
Ponzo	The after-growth which springs up after shifting cultivation.
Taik	An obstruction caused by logs piling up in a stream.
Taungya	Form of Shifting Cultivation.
Tawtama	Cedrela toona.
Thamin	A kind of deer.
Thansha	An adulterant of Cutch made from the bark of "Than" (Terminalia Oliveri).
Thetke Grass	Imperata arundinacea.
Thitsi	Melanorrhea usitata.
Tsaing	Wild cattle (Bos Sondaicus).
Yemane	Gmelina arborea.
Yinma	Chukrasia Velutina.

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